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PAPER PRODUCTION AND PROCESSING - OCCUPATIONAL EXPOSURE AND ENVIRONMENTAL RELEASE STUDY

by

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16. ABSTRACT

This report presents an analysis of chemicals and processes used during the production and processing of paper and paper goods with emphasis on the workplace exposure and environmental release of chemicals from these operations. Reviews of chemical substances in this report are intended for use in developing realistic exposure and release scenarios associated with the review of new chemical substances used in the industry.

In this report, a description of the industry is presented along with profiles of the various process subcategories occurring in the industry. Literature search and discussions with knowledgable persons in the industry during the development of this report has been aimed at developing process descriptions that address occupational exposures to workers, as well as information on the concentration of the release of chemicals to the environment. Process characteristics for each study area, including raw materials and chemicals used are presented along with the description of chemicals in wastestreams and other effluent characteristics. Discussion of waste control and treatment technologies used throughout the industry are also presented. The sources, effects and control of worker exposure to chemicals are described on an industry-wide basis. Specific case studies have also been reviewed to address detail information on occupational exposures to workers (including the number of workers involved, duration of exposure, and workplace concentrations).

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This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement of recommendation for use.

FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollution impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report presents the results of a study to characterize the chemicals and processes used during the production and processing of paper and paper goods with emphasis on workplace exposure and environmental release from these operations. Information presented in this report is to be used to assist in the review of new chemical substances and to develop realistic occupational exposure and environmental release scenarios associated with chemicals used throughout the pulp and paper industry.

Requests for further information regarding the content of this report should be directed to the Organic and Inorganic Chemicals and Products Branch or the Food and Wood Products Branch of IERL-Ci.

David G. Stephan
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ABSTRACT

This report presents an analysis of chemicals and processes used during the production and processing of paper and paper goods with emphasis on the workplace exposure and environmental release from these operations. In this regard, reviews of chemical substances are of particular interest and are intended for use in developing realistic exposure and release scenarios associated with the review of new chemical substances used in the industry.

In this report, a description of the industry is presented along with profiles of the various process subcategories occurring in the industry. Literature search and discussions with knowledgable persons in the industry during the development of this report has been aimed at developing process descriptions that address occupational exposures to workers, as well as information on the concentration of the release of chemicals to the environment. Process characteristics for each study area, including raw materials and chemicals used are presented along with the description of chemicals in wastestreams and other effluent characteristics. Discussion of waste control and treatment technologies used throughout the industry are also presented. The sources, effects and control of worker exposure to chemicals are described on an industry-wide basis. Specific case studies have also been reviewed to address detailed information on occupational exposures to workers (including the number of workers involved, duration of exposure, and workplace concentrations).

This report was submitted in fulfillment of Contract No. 68-03-3015, Work Assignment 7 by S-Cubed under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from February 1982 to October 1983, and work was completed as of April 1984.

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The project management also extends its sincere appreciation for E. C. Jordan Company's helpful and informative input to the literature review. This input includes expertise in the areas of the specific process waste control technologies, concentrations of specific toxic, nonconventional and priority pollutants in "end of the pipe" effluent streams, and the effectiveness of external waste treatment to reduce the final concentrations of these chemicals.

SECTION 1

INTRODUCTION

This report presents the results of a study to characterize the chemicals and processes used during the production of paper and paper goods, with emphasis on work place exposure and environmental release from these operations. This information will assist in EPA's review of Premanufacture Notices (PMN) under the Toxic Substances Control Act (PL 94-469). PMN review includes a review of exposure to humans and to the environment during the manufacturing and processing of chemicals.

For this study, the pulp and paper industry has been described in terms of this industry's major processing technologies. This division of technologies is based on the definition of the paper industry as presented in recent EPA studies to develop effluent limitation guidelines and new source performance standards, and to analyze related economic impacts. These studies are based on the process subcategories of the pulp, paper and paperboard industry as established in 40 CFR, Part 430, by grouping mills which employ similar production and process techniques. Such a grouping has been established so that EPA can develop uniform national effluent limitations and standards which would affect similar mills in a similar fashion in terms of modifications required and costs incurred. For this study, subcategories established by EPA have been further grouped into study areas best suited to the organization of the investigation of process and waste chemicals.

General crewing and exposure patterns in each study area were developed during this study from a NIOSH project conducted to survey, evaluate and document worker exposure to toxic chemicals and harmful physical stresses and related controls to exposure used in the pulp and paper industry. Detailed exposure scenarios were also developed during this study from case studies which review the most documented occurrences of worker exposures to specific chemicals and associated processes. These exposure scenarios provide detailed information on the process characteristics, number of workers and their activities associated with the process and associated chemicals and the concentrations of these chemicals that are likely to occur in the work place during operator activities. In section 6, the case studies presented may serve to supplement the approach taken to establish general crewing and exposure patterns, and the reader is often referred to appropriate case studies during discussions on the development of general crewing and exposure patterns.

Since the detailed exposure scenarios developed in this study account for only a small segment of the total paper industry, additional information has been obtained from NIOSH and OSHA for a broad review of the sources and extent to which workers are exposed to specific chemicals and other significant material agents. This broad review includes a listing of known carcinogens to which workers may be exposed and the identification of specific occupations involving exposure to these chemicals. A broad review of accidents and fatalities due to chemical hazards and acute exposures is also derived from NIOSH and OSHA literature and includes a description of human factors contributing to such chemical hazards.

Of the various sources of data used to identify process and waste chemicals, the most comprehensive is the NIOSH National Occupational Hazard Survey (NOHS) database for pulp and paper mills. To establish this database, NIOSH made visits to many facilities throughout the industry where over 800 chemical agents were identified and related to the various production and manufacturing operations and associated worker occupations.

Each chemical identified during this project is presented in the Chemical Profiles (Appendix A) along with pertinent information summarizing discussions in the text as well as other information which characterizes the chemical. This information includes its occurrence in the industry as a use or waste chemical, its description and physical properties, permissible air and water concentration, synonyms and health effects and safety data for those chemicals known to be hazardous to workers. For many of these chemicals, additional discussion on their occurrence throughout the industry and/or health effects is presented in the main body of the text.

To acquaint the reader with general aspects of the pulp and paper industry, this report presents a brief overview of this industry's technology, production, economics and projected growth, and presents a definition of product sector divisions which are based on grade descriptions defined by the American Paper Institute.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

Of the many chemicals used and released during pulp and paper processing, some are important in terms of both occupational exposure (as process and waste chemicals) and environmental release (emission, effluent and solid waste chemicals). However, many chemicals are known to be significant in only one of these areas.

Among the chemicals released to the environment, many toxic, nonconventional and priority pollutants have been identified in pulp and paper industry discharge waters. Their occurrences throughout the industry have been reviewed in this report. This review includes discussions illustrating the relationship between these pollutants and conventional pollutants (Biological Oxygen Demand, Total Suspended Solids and pH) and water usage. These discussions are centered on data obtained from previous effluent guidelines development studies designed to verify and quantify the presence of conventional, nonconventional, toxic and priority chemical pollutants in industry discharges. Data (when available) is expressed in ranges to account for variations in process conditions.

Information obtained from the industry broad review of chemicals and associated processes indicates that the most significant occupational exposure problems associated with papermaking chemicals include fatal exposures to high concentrations of hydrogen sulfide and other sulfur compound emissions, as well as carbon monoxide and chlorine exposures. OSHA sampling tests have revealed that these chemicals frequently exceed OSHA standards, thus contributing to problems of short term, accidential and acute exposure. Regarding long-term illness in pulp and paper mill workers, more information is needed due to a lack of relevant epidemiologic studies. In addition, plant visits are essential to assess quantitatively the uses and hazards of the numerous chemical additives used throughout the industry.

Although the literature discusses general categories of additives, the problem is to determine which are in wide-spread use and, of those in wide-spread use, which are toxic under the conditions of use. In short, there is a surprising lack of quantitative information on the use and exposure effects of additives throughout the industry.

Moreover, the distinction is seldom made between the quantity of such materials applied and the quantity present in the final product. Most additives are furnished to the mills by chemical suppliers who have technical service representatives to advise on the proper methods for handling and application. Since each pulp furnish and each paper machine has individual characteristics that must be understood for best results, the quantity of additives used may be quite variable. Extensive, additional study is therefore required to quantify the ranges of usage and describe the process variations contributing to such ranges for the many additives used throughout the industry.

For the vast majority of chemicals, information on work place emission sources, worker exposure and other characteristics is scarce. Needs to gather such data have been tempered by the fact that many chemicals occur in such small quantities that worker exposure problems have not been seriously considered.

Regarding the development of generalized job descriptions and crewing patterns, it should be noted that wide variations in these categories create job descriptions that are generally not comparable, since mills combine work tasks depending on equipment layout, automation and complexity. Hence, the number of required workers and the tasks they perform vary considerably throughout the industry. Occupational exposure characteristics for each machine type might therefore be most accurately determined on a plant by plant basis for each paper type. The study area analyses presented in Sections 4 and 5 include discussions and illustrations of equipment, machinery and process operations that can serve as a guide to assess the need for further work to characterize occupational exposure in operations not addressed fully by the development of general crewing and exposure patterns, or in the case studies of specific occupational problems presented in Section 6.

Studies similar to that described in Section 6 (Gas Concentrations in Kraft Mill Work Areas), can be applied throughout the industry to quantify worker exposures to the wide range of organic and inorganic process chemicals and by-products, escaping to the work area. This type of investigation can also be used to assist the development of training programs and safety procedures designed to control or limit worker exposure. Such activities would serve to bolster the benefits obtained from the existing training programs and safety procedures discussed in this report.

For many of the chemicals presented in Appendix A, certain items of data are not available in the literature and are therefore missing from the Chemical Profiles. Moreover, the exact nature of the industrial occurrence of many chemicals (many of which are identified by the NOHS walk through) is not characterized. For these chemicals, additional research is required to establish completely the items of information presented by the Chemical Profiles.

SECTION 3

INDUSTRY DESCRIPTION

This section presents a discussion of the pulp and paper industry's basic product and process divisions and includes an overview of the industry's technological and economic characteristics and trends. The overview discussion briefly reviews many topics pursued in more detail throughout this report. These topics include raw materials and process chemicals, water usage and treatment technology, pollutant chemicals and related control technology and the changing process technology. In order to organize the presentation of the industry's process and waste chemicals, the division of the industry's process technologies is defined in terms of the subcategories developed during previous EPA studies, and study areas developed during this study. A description of this industry's product sectors is presented as defined by the American Paper Institute. The relationship between the industry's process subcategories and product sectors is illustrated and includes discussions of important economic and technological trends occurring within each product sector.

OVERVIEW

All paper and paperboard manufacturing processes are based on the same techniques and operations. Regardless of the form of the end product, certain operations or processes must be performed on the raw material to convert it into a final product. The basic operations are common to all products, but are modified to produce either slight or enormous differences in the final product. Furthermore, all of the products are made from practically the same raw materials-cellulosic fibers. Wood is reduced to a mass of tiny, individual fibers for papermaking by chemical or mechanical pulping processes, or by a combination of the two. In the mechanical or groundwood process, short logs are held against the rough surface of a rotating grindstone made of sandstone or synthetic abrasive material. A shower of water cools the stone and carries away the shredded wood fibers (pulp).

In the chemical pulping processes, the natural plant fibers are separated by dissolving the lignin and other cementing material from wood chips. The lignin is dissolved by heating the chips and cooking liquor at high temperatures and pressures in large pressure vessels called digesters. The three chemical processes commonly used for pulping are the sulfate or kraft, soda, and sulfite processes. Alkaline liquors are used in the sulfate and soda processes; and acid liquor is used in the sulfite process.

The semi-chemical processes employ both chemical and mechanical actions. In these processes, the chips are first given a mild softening treatment with a chemical; then they are reduced to a pulp by mechanical treatment in an "attrition" or "disk" mill. The semi-chemical processes were developed for pulping hardwoods and they are especially suitable for this purpose; also, they increase the yields of pulp from both softwoods and hardwoods. Figure 1 shows the papermaking process in simplified form. Starting from left, either wood chips are poured into the chemical digester ("cooker") or else debarked short pulpwood logs are fed into the mechanical grinder. For papers that must be whitened, the next step is the bleaching process. The loose fibers suspended in water (pulp) then go through a washer, where the pulp is sprayed with water as it revolves on large drums. From there it goes into the beater or into the refiner (jordan), or it may go into the beater first and then into the refiner as well.

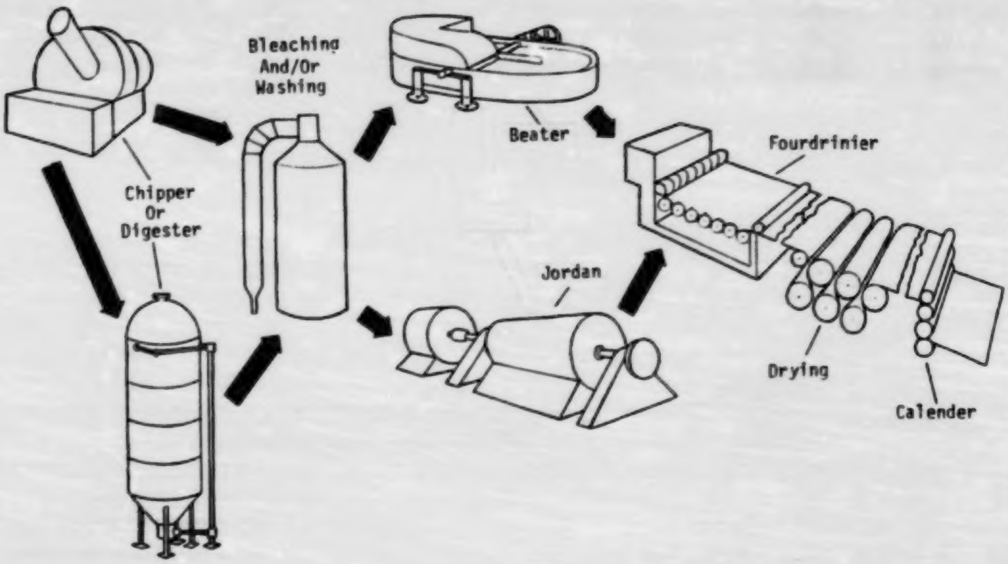

Figure 1 Simplified Form of Papermaking Process

In the beater the fibers are subjected to rubbing or brushing action which cuts, splits, bruises, and frays them in varying degree. The fibers are then more flexible, and have more surface area exposed for fiber bonding. These characteristics result in strong, well-formed paper. For the finer grades of paper, a sizing solution (starch or animal glue) is added to seal pores in the paper and give it a good writing surface. Coloring, if necessary, is also done at this point. In the refiner long fibers are mechanically treated to improve the formation and strength of the sheet. The treatment may also be done by the beater alone.

From here the wet mass of pulp is further diluted with water and fed into a long, broad wire screen where part of the water is drained off and the wet pulp sheet is formed. The wet sheet of pulp is then deposited onto a porous felt cushion which caries it through a series of roller presses which squeeze out more of the water.

The final drying is accomplished by winding the paper through a series of steam-heated rotating drums. Then it is passed through a series of chilled steel rolls to smooth it out and give it uniform thickness. Finally, it is wound into large rolls and cut to the required sizes.

Finishing operations include supercalendering, plating, slitting, rewinding, sheeting, trimming, sorting, counting, and packaging. Ruling, punching, pasting, folding, and embossing are also sometimes considered as finishing operations.

Paper and paperboard differ primarily in the thickness of the products. The U.S. Department of Commerce classifies several categories within each field. Among them:

Newsprint

Newsprint is used for newspapers. Made mainly from groundwood pulp, it also contains about 20% chemical pulp. Because the paper has a high lignin content (the substance that binds the fibers together in the tree), it turns yellow and brittle in a relatively short time.

Printing Papers

Uncoated groundwood, book and coated papers are often grouped together as printed papers. Uncoated groundwood papers contain groundwood and chemical pulps as does newsprint, but there the similarity ends. The groundwood grades contain less groundwood and more chemical pulps than newsprint. The groundwood grades of pulps are frequently bleached and are of a higher quality than those used in newsprint. In addition, the sheets are often sized, supercalendered, clay filled, or otherwise treated for special purposes. Major uses include: directories, magazines, commercial printing, and catalogs. Coated papers are used largely in magazines. Paper coated on only one side is used for can labels. Book papers go into books, magazines, and pamphlets, and are used in commercial printing, as well as in business stationery and envelopes.

Fine papers are among the highest grades of paper made. Some grades are made largely, or entirely, from cotton fiber and found in the more expensive writing papers and envelopes, stock and bond certificates, and for the money we use every day. Most fine papers, however, are made from chemical wood pulp.

Business and industry uses fine papers--both cotton fiber and chemical wood pulp content--for check papers, writing paper, ledger and mimeograph papers, for maps and charts; and for blueprint and other sensitized papers. Many of the greeting cards used today are made from this grade of paper.

Coarse Papers

These are the heavy duty papers used to wrap and package products. Grocers' bags, and the gaily colored notion and specialty bags, are all made of coarse papers, as are paper shipping sacks, such as those used for cement, sugar, and flour. Coarse papers may be converted into a great many special products, including envelopes, gumming paper, asphalting paper, and coin wraps.

Special Industrial Papers

These are made for industrial uses. The surface pulp content, strength, and other characteristics vary according to the specific need. The more important types include abrasive paper, electrical insulation paper, gasket paper, tabulating card stock, filter papers, and absorbent papers.

Sanitary and Other Tissue Papers

Major uses include paper towels, toilet tissue, paper napkins, and facial tissues or paper handkerchiefs. Other tissue papers are used for wrapping tissue, fruit and vegetable wraps, salesbook tissues, pattern tissues, and similar products.

Containerboard

This is the largest single grade of paper made. There are two major kinds: linerboard and corrugating material. Liner and corrugating materials are made into paperboard corrugated shipping containers, also called fiber boxes. Corrugating materials were once made largely from straw, but today are made mainly from hardwood pulp.

Folding Boxboard

Most of the cartons holding dry cereals, toothpaste, soap powders, and other common household products are made from folding boxboard. It is usually made on a cylinder machine, where the outer surface of this board is designed to take a fine printing, while the inner part gives the bulk, rigidity, and protection necessary for a carton.

Special Food Board

This type of boxboard is made from bleached kraft wood pulp on the fourdrinier. It is used to package moist and oily foods. Milk cartons, frozen food packages, ice cream cartons, and paper plates are made from this type of board.

Set-up Boxboard

Made mainly from waste paper, it is much thicker than folding boxboard. Shoe boxes, candy boxes, and jewelry boxes are common products made from set-up boxboard.

Other Paperboard

In this group are such boards as fiber can, tube and drum stock, liners for the gypsum board that may be used as walls in the home, and cardboard.

Wet machine board is so thick it cannot pass through the dryers of the papermaking machine, and must be taken off while still wet. Uses include shoeboard and bindings for books.

Construction

Grades include roofing, floor coverings, automotive felts, and insulating boards.

The pulp and paper industry is one of the world's oldest and largest industries. In the United States, this industry ranks as the ninth largest manufacturing industry, accounting for nearly 3.5% of the value of all manufacturing (1). Pulp and paper industry processes are, for the most part, conservative technologies, most of which were developed in the nineteenth century when the continuous paper machines (fourdrinier and cylinder types) were invented and wood pulping processes were developed. Since then, technical advances have generally involved the progress in engineering process improvements and not radical innovations in the basic technology.

The rate of growth in this industry varies from product to product. However, most of the demand for paper is closely related to the economy and disposal income, with most paper products growing slightly less than the economy. Products with strong competition, such as carbon paper, rigid boxes, gummed tape and wallpaper, generally do not keep pace with economic growth. Sanitary products and corrugated containers, however, are likely to keep pace with economic growth, with flexible packaging and other products geared to services growing faster than the gross national product (GNP). Papers used for computer printouts and office copying and duplicating have grown enormously in the recent past and should continue at a high rate of increase for many years.

The major fibrous raw materials used in the industry are wood- pulp and waste paper. Both hardwood and softwood species are used as suitable pulpwood in the form of logs (roundwood) or in chips, saw- dust, or other residuals of lumber and wood processing. The use of hardwoods has been increasing due to improvements in pulping tech- nology. Yields from hardwoods tend to be higher and their properties are preferred for high stiffness rather than high strength for such applications as corrugated medium. Waste paper - the second major fibrous raw material - is taken primarily from old corrugated containers, followed by newspapers and office paper collected from high volume users. Unsorted waste paper can also be used as a low-cost fuel, in cases where it is more profitable to burn than to sort and recycle it.

Millions of tons of chemicals are used each year for pulping, bleaching, and papermaking. The pulp and paper industry is the sixth largest consumer of chemicals, preceded only by the chemical, textile, rubber and plastics fabricating, agricultural, and petroleum refining industries (1). About one-quarter ton of chemicals is used in the manufacture of every ton of paper and paperboard. The major chemicals used are heavy inorganic chemicals for pulping and bleaching. In Table 1, the consumption of these major chemicals is shown for 1975 to 1978.

Table 1 CONSUMPTION OF MAJOR PULPING AND BLEACHING CHEMICALS BY THE PAPER INDUSTRY, 1975-1978 (1) (In Thousand Of Tons)

Chemical	1975	1976	1977	1978
Sodium Hydroxide	1,710	1,890	1,960	1,980
Chlorine	1,190	1,380	1,450	1,370
Calcium Oxide	970	1,020	1,030	1,050
Sodium Sulfate	860	860	840	850
Sulfuric Acid	470	555	600	640
Sodium Carbonate	360	380	400	415
Sodium Chlorate	155	190	210	255
Sodium Chloride	150	215	230	250
Sodium Sulfite	165	170	170	175
Sulfur	115	120	160	175
Total	6,145	6,780	7,050	7,160

Of the numerous chemicals used as additives in papermaking, many are added to the matrix of fibers as the sheet is being formed. Most are added to the furnish during beating or at the wet end of the papermachine. However, many machine aids such as defoamers are added when needed at any point in the sheet formation. Other chemical specialities are applied after the sheet is formed on the paper machine (on-machine) or in a separate operation in another plant (off-machine). The use of specific additives depends on the type of paper product produced. The extent to which various additives are used throughout the pulp and paper industry is not fully known.

The pulp and paper industry is the third largest industrial user of water, following only the primary metals and chemical industries. The reuse of water in the pulp and paper industry is approximately 3.5 times the water intake. This is due primarily to the use of saveall, which recover fibers and fillers lost in papermaking, while returning water to the process.

The most common treatments for effluent stream pollutants occurring in the various pulping and papermaking processes are sedimentation, aeration in ponds and lagoons and coagulation. Over half the water discharged in the industry is treated to remove a variety of suspended solids such as fine fibers and fillers, organic materials of high biochemical oxygen demand (BOD) such as lignins, tannins, and wood sugars, and a variety of bleaching chemicals. With the use of savealls, the problem of suspended solids such as fibers and pigments in papermaking effluent streams is reduced. In pulping processes, dissolved organic materials with high BOD demand are the pollutants of concern.

Throughout the industry, solids are commonly removed from effluent streams by primary treatments, such as settling basins and clarifiers. Sludges from these operations are either used in landfills or are incinerated. Secondary treatments, used to remove dissolved organic matter, typically involve the use of stabilization ponds which oxidize by natural processes. More recent treatment methodologies involve the use of aerators and the direct application of oxygen.

Chemical recovery systems are also used to reduce pollutants in pulping process wastestreams. Organic material in spent liquor, for example, is often burned for fuel. Recovery systems are used to recover such economically recyclable products as the lignosulfonates.

Particulates, sulfur dioxide and organic sulfur compounds which present odor problems are primarily emitted as air pollutants from pulping rather than papermaking processes. Although little chemical recovery is practiced in these wastestreams, sulfur dioxide can be recovered; however, it is usually uneconomic to do so. Incineration, precipitation and scrubbing are the commonly practiced emission control technologies.

Two areas gaining more attention in recent years are fiber recovery and energy savings. In 1978, approximately 53% of fibrous raw material was derived from recovered materials (22% from waste paper, 30% from forest and manufacturing residues). At that time, hog fuel (wood waste materials, including bark, shavings, sander dust, log yard cleanup, and sawdust) use increased from 5.5 million tons in 1972 to 12 million tons in 1978. Clearly, a conflict between residual materials as a fiber source or for energy generation has been developing (2).

Research and development has never been a major activity for the pulp and paper industry. In recent years, research has focused as much on air and water pollution control as it has on process changes designed to increase productivity. Studies by the American Paper Institute indicate an annual investment requirement of $10 billion per year during the remainder of the 1980's to meet growing domestic and foreign demand potentials in the industry, maintain environmental, health safety standards and continue to improve fuel efficiency (3). The most commercially attractive innovations, which are likely in the near future, will be those which reduce fiber requirements, increase yields, reduce effluent loads and reduce energy needs.

Technological innovations currently being introduced to the industry include thermo-mechanical pulping, displacement bleaching and washing and computerized process control. Oxygen pulping and bleaching, pretreatment of wood chips with hydrogen sulfide in the sulfate (kraft) process and polysulfide pulping with sulfate are also commercially feasible.

Thermo-mechanical pulping, which was developed as a modification of the refiner groundwood process, produces a high quality pulp and has been gaining in production capacity in recent years.

Polysulfide pulping is a modification of the kraft process where elemental sulfur is added directly to the white liquor. With this modification, the amount of cellulose and hemicelluloses that normally goes into solution during cooking are reduced and pulp yields are considerably higher.

Some neutral sulfite semi-chemical (NSSC) pulp processes have been converting to a no-sulfur pulping process in order to reduce sulfur emissions. No-sulfur pulping uses soda ash in combination with caustic soda as the principal pulping agent.

Anthraquinone pulping is a kraft and soda pulping modification where very small quantities of anthraquinone are added to the cooking liquor. Anthraquinone speeds up the pulping process and also increases yields. This process was developed in Canada and is currently used in Japan. U.S. pulp producers are waiting for FDA approval of its use in papergrade pulps for food packaging products (1).

Oxygen bleaching has been used in South Africa since 1970 as a first-stage replacement of chlorination in a sequence using oxidation, extraction with alkali, hypochlorite, chlorine dioxide, extraction, chlorine dioxide (OEHDED). In this process, unbleached pulp is mildly acidified with sulfuric acid, washed and treated to absorb magnesium oxide particles. The treated pulp is then dispersed in a solution of caustic soda and fed into a fluffer for treatment with steam and oxygen (1). Oxygen bleaching produces kraft pulps of higher brightness with less cellulose degradation. Its use in the first stage results in a lower consumption of chlorine in subsequent stages and dramatically reduces effluents. Spent liquor is considerably less toxic and much less water is used. Oxygen bleaching stages are currently being employed at two plants in the U.S. (1).

Research has also been done in the use of ozone in bleaching pulp. Ozone has been shown to be highly effective as a bleach. However, concentrations must be kept low to prevent degradation of the cellulose and the lignin portions of the pulp.

STUDY AREAS AND SUBCATEGORIES

During previous EPA studies to develop uniform national effluent limitations and standards (4,5,6,7,8), the pulp and paper industry was divided into units called subcategories. These subcategories were formed by grouping mills which employ similar production and process techniques so that the development of limitations and standards would affect similar mills in a similar fashion in terms of modifications required and costs incurred. Factors influencing the development of these subcategories included variations in production processes and raw materials used, differences in wastewater characteristics and available treatment technologies. For the purposes of this study, the previously developed subcategories have been further regrouped into "study areas" best suited to the investigation of process and waste chemicals. In Table 2, the grouping of these process study areas and

Table 2 PAPER PRODUCTION AND PROCESSING - MAJOR INDUSTRY PROCESSSTUDY AREAS AND SUBCATEGORIES

- PULPWOOD PREPARATION
- KRAFT PULP PROCESSING
    1. Unbleached Linerboard and Bags
    2. Bleached Dissolving Pulp
    3. Bleached Market Pulp
    4. Bleached Paperboard, Coarse, Tissue (BCT)
    5. Bleached Fine Papers
- SODA PULP PROCESSING
- SULFITE PULP PROCESSING
    1. Papergrade Blow Pit Wash
    2. Papergrade Drum Wash
    3. Dissolving Grade
- NEUTRAL SULFITE SEMI-CHEMICAL (NSSC) PULP PROCESSING
    1. Sodium Base
    2. Ammonia Base
    3. Unbleached Kraft Cross Recovery
- MECHANICAL (GROUNDWOOD) PULP PROCESSING
    1. Chemi-Mechanical (CMP)
    2. Thermo-Mechanical (TMP)
    3. Coarse, Molded, Newsprint (CMN)
    4. Fine Papers
- WASTE PAPERBOARD PULP PROCESSING
- DEINK PULP AND PAPER PROCESSING
- PAPER AND PAPERBOARD MAKING
    1. Fine Papers
    2. Tissue Papers
    3. Tissue from Waste Paper
    4. Light Weight
    5. Filter and Nonwoven
    6. Paperboard
- BUILDING PAPER AND BOARD MAKING
- MOLDED WASTE PAPER PROCESSING

subcategories is presented. A brief description of each subcategory in this grouping is presented as follows:

Pulpwood Preparation

This study area involves operations intended to prepare wood chips for pulping. These operations, which are integrated with the other pulping subcategories, involve the wood supply (logs, purchased chips, sawdust, sawmill residues, etc.). The specific nature of pulpwood preparation operations often depends on the nature of the pulping process for which this material is intended.

Unbleached Kraft Linerboard and Bags

Unbleached kraft mills use a "full cook" process to produce kraft pulp, using a highly alkaline cooking liquor containing sodium hydroxide and sodium sulfide. This basic kraft process is common to all kraft subcategories. In this subcategory of mills, the pulp is not bleached and is used to manufacture the typical unbleached kraft products, which include linerboard (the smooth facing of corrugated boxes), wrapping paper, and paper for grocery bags and shipping sacks.

Bleached Kraft Dissolving Pulp

Bleached kraft dissolving pulp mills produce pulp by a "full cook" process, utilizing a highly alkaline sodium hydroxide and sodium sulfide cooking liquor. Included in the manufacturing process is a "pre-cook" operation termed pre-hydrolysis. The pulp is subsequently highly bleached and purified to make dissolving pulp, used principally for the manufacture of rayon and other products requiring virtual absence of lignin and a very high alpha (pure) cellulose content.

Bleached Kraft Market Pulp

Bleached kraft market pulp mills produce pulp by a "full-cook" process utilizing a highly alkaline sodium hydroxide and sodium sulfide cooking liquor which is subsequently bleached. The product is called papergrade market pulp.

Bleached Kraft Paperboard, Coarse, Tissue (BCT)

The bleached kraft paperboard, coarse, tissue (BCT) papers subcategory includes the integrated production of bleached kraft pulp and paper. Integrated production is considered to be pulp and paper manufacturing operations where all or part of the manufactured pulp is processed into paper at a common or adjacent site. The kraft pulp is produced in a "full cook" process utilizing a highly alkaline sodium hydroxide and sodium sulfide cooking liquor which is subsequently bleached. The principal products include paperboard (B), coarse papers (C), tissue papers (T), and market pulp.

Bleached Kraft Fine Papers

The bleached kraft fine papers subcategory includes the integrated production of bleached kraft pulp and paper. The principal products are fine papers which include business, writing, printing papers, and market pulp.

Soda Pulp and Paper Processing

This subcategory includes the integrated production of bleached soda pulp and paper. Soda pulp is produced by a "full cook" process utilizing a highly alkaline sodium hydroxide cooking liquor and is subsequently bleached. The principal products are fine papers which include printing, writing, and business papers.

Papergrade Sulfite Blow Pit Washing

This subcategory includes integrated production of sulfite pulp and paper. The sulfite pulp is produced in a "full cook" process using an acidic cooking liquor of sulfites of calcium, magnesium, ammonia, or sodium. Following the cooking operations, the spent cooking liquor is separated from the pulp in the blow pits. The principal products made by this process are tissue papers, newspapers, fine papers, and market pulp.

Papergrade Sulfite Drum Wash

This subcategory includes the integrated production of sulfite pulp and paper. The sulfite pulp is produced in a "full cook" process using an acidic cooking liquor of sulfites of calcium, magnesium, ammonia, or sodium. Following the cooking operations, the spent cooking liquor is washed from the pulp on vacuum or pressure drums. Also included are mills using belt extraction systems for pulp washing. The principal products made from pulp manufactured by this process are tissue papers, fine papers, newspapers, and market pulp.

Dissolving Grade Sulfite Pulp

The dissolving grade sulfite pulp subcategory includes mills which produce pulp from softwoods by a "full cook" process using strong solutions of sulfites of calcium, magnesium, ammonia, or sodium. The pulp is subsequently highly bleached and purified to produce viscose, nitration, cellophane, or acetate grades which are used principally for the manufacture of rayon and other products that require the virtual absence of lignin.

Neutral Sulfite Semi-Chemical (NSSC) Sodium Base

This subcategory includes mills where pulp is produced using a process that involves the cooking of wood chips under pressure using a sodium base neutral sulfite semi-chemical process. The cooked chips are usually refined before being converted on-site into board or similar products. The principal products include corrugating medium, insulating board, partition board, chip board, tube stock, and specialty boards.

NSSC Ammonia Base

NSSC ammonia base mills are the same as those described above, except that ammonia is used as the cooking liquor base. Ammonia cannot be recovered for reuse and it imparts different characteristics to the wastewater.

Unbleached Kraft Cross Recovery

NSSC/unbleached kraft mills with cross recovery are combined mills in which spent sodium base NSSC liquor is recovered in the kraft mill recovery system. Pulp is produced on site to produce both linerboard and corrugating medium used in the production of corrugated boxes and other products.

Chemi-Mechanical Pulp and Paper Processing

This subcategory includes the integrated production of chemi-mechanical groundwood pulp and paper. The chemi- mechanical groundwood pulp is produced utilizing a chemical cooking liquor to cook the wood partially followed by mechanical defibration by refining with or without brightening, resulting in yields of 90% or greater. The principal products include fine papers, newsprint, and molded fiber products.

Thermo-Mechanical Processing

The thermo-mechanical subcategory includes the production of thermo-mechanical groundwood pulp and paper. Thermo-mechanical groundwood is produced by a brief cook utilizing steam, with or without the addition of cooking chemicals such as sodium sulfite, followed by mechanical defibration by refiners which are frequently under pressure, with or without bringhtening, and resulting in yields of approximately 95% or greater. The principal products of this process are market pulp, fine papers, newsprint, and tissue papers.

Mechanical-Coarse, Molded, Newsprint

The coarse, molded, newsprint (CMN) papers subcategory includes the integrated production of groundwood pulp and paper. The groundwood pulp is produced, with or without brightening, utilizing mechanical defibration only, employing either stone grinders or refiners. The principal products made by this process include coarse papers (C), molded fiber products (M), and newsprint (N).

Mechanical-Fine Papers

The fine papers subcategory includes the integrated production of groundwood pulp and paper. The groundwood pulp is produced, with or without brightening, utilizing mechanical defibration only, employing either stone grinders or refiners. The principal products are finer papers which include business, writing, and printing papers.

Waste Paperboard Processing

Waste paperboard mills are those in which waste paper is repulped and accounts for at least 80% of the fiber used primarily to produce unbleached folding board products such as soap cartons and bottle carriers. No deinking is practiced in connection with paperboard production, but the product is frequently upgraded with an asphalt dispersion process.

Deink Pulp and Paper Processing

The deink subcategory includes the integrated production of deinked pulp and paper. The deinked pulp is produced by applying an alkaline treatment to waste paper to remove contaminants such as ink and coating pigments. The pulp is usually bleached or brightened to produce such products as printing, writing and business papers, tissue papers, and newsprint.

Non-Integrated Fine Papers

This subcategory includes non-integrated mills which produce fine papers from wood pulp or deinked pulp prepared at another site. The principal products of this process are printing, writing, business, and technical papers.

Non-Integrated Tissue Papers

This subcategory includes non-integrated mills which produce tissue papers from wood pulp or deinked pulp prepared at another site. The principal products of this process include facial and toilet papers, glassine, paper diapers, and paper towels.

Non-Integrated Tissue from Waste Paper

This subcategory includes non-integrated mills which produce tissue papers from waste papers (FWP) without deinking. The principal products made by this process include facial and toilet papers, glassine, paper diapers, and paper towels.

Non-Integrated Lightweight Papers

This subcategory includes non-integrated mills where lightweight or thin papers are produced from wood pulp or secondary fibers prepared at another site and from nonwood fibers and additives. The principal products made at these mills include uncoated thin papers, such as carbonizing papers and cigarette papers, and some special grades of tissue such as capacitor, pattern, and interleaf.

Non-Integrated Filter and Nonwoven

This subcategory includes non-integrated mills where filter papers and nonwoven items are produced from a furnish of wood pulp, secondary fibers, and nonwood fibers prepared at another site. The principal products made at these mills include filter and blotting papers, nonwoven packaging and specialties, and technical papers.

Non-Integrated Paperboard

This subcategory includes non-integrated mills where paperboard is produced from wood pulp or secondary fibers prepared at another site. The principal products made at these mills include linerboard, folding boxboard, milk cartons, food board, chip board, pressboard, and other specialty boards. Mills where electrical grades of board or matrix board are produced are not included in this subcategory.

Building Paper and Board Making

This subcategory includes mills where heavy papers used in the construction industry are produced from cellulosic fibers derived from waste paper, wood flour and sawdust, wood chips, and rags. Neither bleaching nor chemical pulping processes are employed on-site.

Molded Waste Paper Processing

This subcategory includes mills where molded products are produced from waste papers without deinking. Products include molded items such as fruit and vegetable packs and similar throw-away containers and display items.

SUBCATEGORIES AND PRODUCT SECTORS

In addition to the division of the pulp and paper industry into study areas and subcategories, the industry has been divided into product sectors which constitute aggregations of the important groups of intermediate and end products which the industry manufactures. These product sector divisions, which are presented in Table 3, are based on grade descriptions defined by the American Paper Institute and were investigated during a survey of the industry (308 Survey) for the purposes of an economic impact analysis of proposed EPA Limitations and Standards (3). This section describes each product sector and presents lists of each sector's major producers and a discussion of economic and technological trends based on information presented in the economic impact analysis.

In Table 4, the relationship between the product sectors and the industry's subcategories is illustrated. The table is organized as a matrix in which the various product sectors are related to each industry subcategory. In this table, a given cell entry is the percentage of a subcategory's production which goes into the production of the various product sectors. For example, nearly all of the production of Tissue from Waste Paper (92%) goes into the manufacture of Tissue paper while only about (5%) goes into the manufacture of Special Industrial paper.

Table 3 PRODUCT SECTORS, YEARLY PRODUCTION AND NUMBER OF MILLS (3)

Product Sector Name	308 Survey Yearly Production (10^3 Short Tons)	Number Of Mills
Dissolving Pulp	1361	9
Market Pulp	5057	76
Unbleached Kraft Paper	3704	44
Bleached Kraft Paper	1093	40
Glassine and Greaseproof Papers	220	10
Tissue	4116	89
Special Industrial Papers	602	63
Newsprint	3944	24
Coated Printing Papers	4546	45
Uncoated Freesheet	6442	103
Uncoated Groundwood Paper	1179	22
Thin Papers	396	21
Solid Bleached Bristols	860	22
Cotton Fibre	120	23
All Other Paper	213	22
Unbleached Kraft Linerboard	13104	48
Bleached Kraft Linerboard	95	6
Bleached Foldingboard	1918	17
Solid Bleached Board	1621	19
Semi-Chemical Corrugating Medium	4222	37
Recycled Linerboard	759	25
Recycled Corrugating Medium	1160	27
Recycled Foldingboard	2894	75
Construction Paper and Board	2841	99
Molded Pulp Products	279	14
All Other Paperboard	2080	68

Dissolving Pulp

Dissolving pulp is defined as highly refined bleached sulfite or sulfate pulp with a high content of alpha (pure) cellulose fiber. There are six U.S. firms that produce dissolving pulp. These producers are:

ITT-Rayonier, Inc.
The Proctor & Gamble Co.
Alaska Lumber & Pulp co.
International Paper Co.
Louisiana-Pacific Corp.
Weyerhaeuser Co.

Dissolving pulp is high purity chemical cellulose which is converted by chemical processes into rayon, cellophane, acetate, plastics, and cellulose derivatives. U.S. capacity to produce dissolving pulp remained nearly [illegible] poorly

Table 4 PERCENTAGE OF SUBCATEGORY PRODUCTION IN EACH PRODUCT SECTOR (3)

PRODUCT SECTOR	Dissolving Kraft	Market Bleached Kraft	BCT Bleached Kraft	Fine Bleached Kraft & Soda	Unbleached Kraft (Linerboard)	Unbleached Kraft (Bag)	Semi-Chemical	Unbleached Kraft & Semi-Chemical	Dissolving Sulfite Pulp	Papergrade Sulfite	Groundwood - Thermo-Mechanical	Groundwood - Coarse, Molded, Newsprint	Groundwood - Fine Papers	Miscellaneous Integrated	Deink (Fine Papers)	Deink (Newsprint)	Deink (Tissue)	Tissue from Wastepaper	Paperboard from Wastepaper	Wastepaper Molded	Builders' Paper & Roofing Felt	Miscellaneous Secondary Fiber	Nonintegrated Fine Papers	Nonintegrated Tissue Papers	Nonintegrated Lightweight	Nonintegrated Filter & Nonwoven	Nonintegrated Lightweight - Elec. Allow.	Nonintegrated Paperboard	Miscellaneous Nonintegrated
Dissolving Pulp	•								79																				
Market Pulp	•	89	16	9	•	•	•		21	•				12								•		•					
Unbleached Kraft						34		18						8			•	•	•				•					•	2
Bleached Kraft				•		•								4			•	•	•				•	•	•			•	5
Glassine										•				•									•						12
Tissue		•	•	•		•	•			44				4			95	92	•			7	•	98	•				•
Special Industrial				•						•				1				5	•			•	•	•		95	•	•	23
Newsprint											•	•		16		•													
Coated Printing				37									79	6								•	25		•			•	•
Uncoated Freesheet				42			•			38		•	•	9	•							28	55		•	•		•	13
Uncoated Groundwood				•							•	•	•	4	•							•	•						
Thin Papers				•		•							•					•				•	•		63		•		•
Solid Bleached Bristols			•	•			•			•				2								•	•						•
Cotton Fibre																							2			•			•
All Other Paper			•	•						•									•			•	•			•		•	•
Unbleached Linerboard					•	51		56						17															
Bleached Linerboard		•	•																										
Bleached Foldingboard		•	42											5					•				•						
Solid Bleached Board		•	21											6					•										
Semi-Chemical Corrugating							87	19		•				4															
Recycled Linerboard																			9			•							
Recycled Corrugating							•							•					15			•							
Recycled Foldingboard							•			•				•					40			•	•						
Construction Paper & Board														•					12		100	•						•	•
Molded Pulp												•		•						•									
All Other Paperboard						•		7		•									22	•		•						•	•
Total Production (10^6 Short Tons/Year)	•	2.1	2.3	5.1	5.4	3.3	2.9	5.2	0.9	2.1	•	•	1.4	19	0.4	•	0.6	8.3	6.5	0.1	1.6	1.2	2.1	1.2	0.3	0.1	•	0.1	0.9
Number of Mills	•	10	8	21	17	11	20	10	6	16	•	•	9	81	5	•	13	18	150	8	61	16	41	26	11	14	•	11	35

•Publication would disclose information about an aggregate of four or fewer mills.
Row and column sums may, therefore, not equal 100%.

Glassine

unchanged through the 1970's. This is because U.S. demand for dissolving pulp has decreased slowly since 1974 and will continue to decrease in the future. The market for textile filament and staple rayon, two key end uses of dissolving pulp, is depressed due to excess polyester production capacity. Demand for high-tenacity rayon (tire cord) is nil. Cellophane and textile acetate production have also decreased, but acetate tow production for cigarette filters remains strong. The long-term projection of export demand is favorable.

Market Pulp

Market pulp is produced for sale to pulp consumers. All types of pulp except dissolving pulp are included. There are 47 U.S. firms that produce market pulp. The major producers are:

Weyerhaeuser Co.
Scott Paper co.
Georgia-Pacific Corp.
International Paper Co.
Crown Zellerbach Corp.
Hammermill Paper Co.
Louisiana-Pacific Corp.
Bowater, Inc.

Economic trends and technology changes impact both production of and demand for market pulp. The most significnt technological change is the long-term substitution of bleached sulfate for bleached sulfite pulp. This is largely because bleached sulfite pulp capacity has remained static (as a result of pollution-related closures). Also, southern mills can use only kraft pulping processes on southern pine trees, and there has been recent expansion of southern pulp mills.

Market pulp is freely traded throughout the world; the U.S. market is highly sensitive to world market conditions. Traditionally, the U.S. is a net importer of paper grade pulps.

Imports of Canadian market pulp accounted, in the mid-1970s, for over 50% of the bleached paper grade market pulp consumed in the U.S. Many Canadian pulp mills specialize in market pulp production rather than forward integrating to on-site paper production, since they have competitive advantages for high-grade pulp over U.S. mills and Canadian pulp can be exported duty-free, while most paper products cannot.

Domestically produced bleached market pulp is a residual product, since most domestic paper producers sell what they can after meeting their own papermaking requirements. Thus, if capacity is tight in the U.S. tissue, printing, and freesheet paper sectors, the supply of bleached market pulp is also likely to be tight.

Unbleached Kraft Paper

This product sector is comprised of paper containing more than 50% unbleached sulfate wood pulp and is used for wrapping paper, shipping sacks, bags and sacks other than shipping sacks. Of the 29 U.S. firms that produce unbleached kraft paper, the major producers are:

St. Regis Paper Co.
Continental Forest Industries
International Paper Co.
Union Camp Corp.
Crown Zellerbach Corp.
Georgia-Pacific Corp.
Boise Cascade Corp.
Gulf States Paper Corp.
Hudson Pulp & Paper Corp.
Longview Fibre Co.

Shipments of unbleached kraft papers peaked in 1974. Within this sector, shipments of unbleached kraft wrapping and converting paper have declined in absolute terms since 1974, while shipments of shipping sack have remained constant (due in part to several mill strikes in 1978). Unbleached grocery bag and sack shipments peaked in 1978. These and shipping sacks have withstood recent plastics competition due to better packaging properties at a competitive unit cost.

Reasons why consumption of products traditionally wrapped in unbleached kraft packaging papers has increased faster than demand for these papers include:

- The durability of plastic wraps and bags
- Use of lower basis weight papers
- The printability of plastic products
- An increased proportion of total food expenditures spent on eating out.

Bleached Kraft Paper

Bleached kraft paper is paper used for food wrap (delicatessen paper, butcher paper), shipping sacks and other bags and sacks and for other converting papers which contain more than 50% bleached kraft woodpulp. Of the 30 U.S. firms that produce bleached kraft paper, the major producers are:

Crown Zellerbach Corp.
International Paper Co.
Longview Fibre Co.
St. Regis Paper Co.
Scott Paper Co.
Union Camp Corp.
James River Corp.
Menominee Paper Co., Inc.

The chief competition for packaging material for bleached kraft paper is high-density polyethylene bags which penetrated the bleached bag market heavily in the 1970s and have captured new markets as they have opened up. Plastic bags and wraps are competitively priced and have many superior user characteristics with respect to bleached bag, sack, and wrap. Among the most important plastics' inroads into the bleached kraft paper market have been the switch by many supermarkets to low-density polyethylene films for packaging and the increased use by farm fertilizer producers for plastic sacks rather than 50-pound bleached kraft shipping sacks. Many retail merchandise stores have also switched to plastic bags due to:

- higher consumer appeal;
- tear resistancy with associated light weight;
- good printability;
- multicolor characteristics;
- acceptability of small orders so small stores can have their own printed bags; and
- easy storage due to light weight and compactness.

The only bright spot in the bleached bag market has been the fast-food industry. Usage in this sector increased rapidly in the 1970s, but the upswing in this market has been overwhelmed by the loss of share in other bleached bag markets.

Glassine and Greaseproof Papers

These papers are used for industrial converting and include vegetable parchment and some bleached and unbleached sulfite packaging papers. Sulfite (papergrade) and non-integrated fine papers are two study areas that commonly produce these papers. The 8 U.S. firms that produce glassine and greaseproof papers are:

St. Regis Paper Co.
Phillips Morris Industries Paper Group
Deerfield Specialty Papers, Inc.
James River Corp.
Crown Zellerbach Corp.
Mosinee Paper Corp.
Westfield River Paper Co., Inc.
Weyerhaeuser Co.

Economic trends and technology changes have affected glassine and greaseproof paper in much the same way as bleached kraft papers. The major recent trend has been severe competition from plastics. In general, higher quality glassine and greaseproof packaging materials have held out against inroads by plastics, while lower grades have not.

Tissue

Tissue includes sanitary grades (toilet, facial, napkin, toweline, sanitary napkin, diaper, whipper, and special sanitary papers) for brand-name sale in supermarkets and drugstores and sanitary grades for industrial use and waxing, wrapping, wadding and miscellaneous grades. There are 42 U.S. firms that produce tissue. The major producers are:

Scott Paper Co.
The Proctor & Gamble Co.
Kimberly-Clark Corp.
American Can Co.
Crown Zellerbach Corp.
Fort Howard Paper Co.
Georgia-Pacific Corp.
Brown Co.

In the 1950s and 1960s, consumer tissue displaced reusable fabrics in the napkin and towel product categories. By roughly 1968 this displacement was completed. Future demand for tissue products will relate closely to factors such as consumer disposable income and household growth (since tissue displacement of reusable fabrics has subsided). Consumer tissue is, and is expected to continue to be, more recession-proof and less subject to cyclical swings in consumption levels than the pulp and paper industry, or the economy as a whole. Many consumer tissue producers rely heavily on non-price incentives to market their products, in contrast to the majority of paper and paperboard products producers whose sales of commodities are almost entirely based upon price considerations.

The only economical substitute for consumer tissue is a return to reusable cloth fabrics. A new process to produce fluffier tissue using less pulp has very recently been developed.

Industrial tissue products may contain a large amount of recycled material in addition to, or as a substitute for, virgin wood pulp. Much of it is therefore produced in non-integrated secondary fiber mills. Industrial tissue demand closely follows employment patterns and consumption is based almost solely on price (rather than on non-price characteristics as in the consumer tissue sector). Demand for industrial tissue is less recession-proof than demand for consumer tissue, and fluctuates as employment and GNP fluctuate. It is likely that future industrial tissue production will shift toward large vertically integrated producers and away from the urban based smaller non-integrated producers. Though the integrated producers use more virgin fiber in their furnish, which is more costly than waste fiber, the economies of scale associated with large operations, the present relatively low cost of company-owned wood, and the ability to offer consumers higher quality products will create difficulties for the marginal, non-integrated producers. In addition, it is possible that increase in industrial tissue prices may cause some consumers to economize on consumption.

Special Industrial Papers

These papers are designed for special industrial uses, such as abrasive paper, absorbent paper, cable paper, electrical insulation and similar grades. There are 40 U.S. firms that produce special industrial paper. The major producers are:

Boise Cascade Corp.
Filter Materials, Inc.
Hollingsworth & Vose Co.
James River Corp.
Knowlton Brothers
Mosinee Paper Corp.
Prairie State Paper Mills, Div. of Chippewa Paper Prod. Co.
The Proctor & Gamble Co.

Though there are few direct substitute materials for special industrial paper, a number of the end products such as decorative laminates and luggage compete with substitute products made from other materials. Overall, demand for special industrial paper correlates well with the industrial production index, since special industrial paper has a wide variety of technical and industrial applications.

Newsprint

Newsprint is made largely from groundwood pulp and is used cheaply in the printing of newspapers. Of the 16 U.S. firms that produce newsprint, the eight major producers are:

Boise Cascade Corp.
Bowater, Inc.
Garden State Paper Co., Inc.
International Paper Co.
Kimberly-Clark Corp.
Nekoosa Papers, Inc.
Publishers Paper Co.
St. Regis Paper Co.

Demand for newsprint depends on newspaper advertising, circulation, and commercial printing demand. Commercial printing is the largest non-newspaper use of newsprint. Newsprint quality for commerical printing is almost that of uncoated groundwood, the improvement in quality coming from technological innovations. All newsprint uses correlate closely to growth in GNP as well as measures of total consumer expenditures, new car expenditures, corporate profits, real disposable income, and number of households. Newspaper advertising faces stiff competition from radio, TV advertising, and other printed media. Several factors, including new printing technology, product development by newsprint producers, the low cost of newsprint relative to other printing grades, and newspaper advertising gains, have lead to a recent large growth in U.S. demand for newsprint.

Coated Printing Papers

Coated printing papers are bleached paper with a coated weight of at least 2-1/2 pounds on either side and at least 50% of the coating consisting of pigment. Among the specific products included in the coated printing paper products sector are coated-one-side and coated-two-side papers. There are 30 U.S. firms that produce coated printing paper. The major producers are:

Blandin Paper Co.
Champion International
Consolidated Papers, Inc.
Crown Zellerbach Corp.
International Paper Co.
Mead Corp.
St. Regis Paper Co.
Westvaco Corp.

Coated printing paper production can be divided roughly into 88% coated-two-side and 12% coated-one-side. Coated-one-side papers are almost entirely (85%) used for labels and wraps, especially in the processed food industry. Changes in packaging technology, cost, and consumer preferences threaten continued growth here due to:

- consumer acceptance of plastic wraps, labels, and bottles; and
- large increase in coated paper prices due to market tightness created by demand for coated-two-side papers, while plastic price increases have been very low over the same time period.

In general, the price of plastic substitutes relative to coated-one-side paper helps determine the degree of plastic's penetration into this market.

Coated-two-side papers have grown recently due largely to consumer preference for high-quality media and advertising paper, their excellent printing qualities and the availability of extensive forest resources from which producers make the bleached chemical pulps used as the furnish for coated freesheet papers. Coated-two-side papers will benefit from the continuation of the current U.S. advertising boom, especially if cost differences between printed and electronics media increase.

There are three noteworthy long-term trends for coated-two-side papers. The first is a long-term trends towards use of lower basis weight paper in response to higher postal rates. The second is that when the economy is on a cyclical upswing, the proportion of high-quality papers increases. The third is that technology advancements improving the quality of uncoated groundwood may create future competition for coated-two-side papers.

Uncoated Freesheet

This product sector includes bleached uncoated printing and writing papers containing not more than 25% groundwood pulp in their furnish. Such papers as off-set, tablet, envelope, business (bond, ledger, memo, duplicator), form bond, cover and text and book paper are included. There are 53 U.S. firms that produce uncoated freesheet. The major producers are:

Boise Cascade Corp.
Champion International
Hammermill Paper Co.
International Paper Co.
Mead Corp.
Nekoosa Papers, Inc.
Union Camp Corp.
Weyerhaeuser Co.

Demand for uncoated freesheet papers has increased rapidly in the past 20 years. The underlying causes are as diverse as the markets which use uncoated freesheet. Among these causes are:

- increases in demand for business forms, created largely by computers;
- office automation and concomitant demand for copy, electrical typewriter and duplicator papers, etc.;
- increases in offset printing use and devlopment of commerical printing as a major market; and
- very low nominal price increases which offer an incentive to use these papers (the average price for uncoated book papers was actually lower, in nominal terms, in 1973 than in 1960).

This very competitive sector underwent significant capacity expansions in the 1960s. High operating rates, needed to offset large capital investment costs, and low variable cost increases combined in the 1960s and early 1970s to keep prices low. However, suppliers, hurt by excessive inventories in 1975, are now less prone to expand capacity, suggesting a future of infrequent large increments of capacity increase (following periods of very high capacity utilization).

Business demand for several types of uncoated freesheet, (business forms, computer stock, off-set paper for commerical printing and other converting, business papers, and book papers) remains strong, as do future growth prospects. Cover and text papers probably will not grow due to consumer acceptance of lower priced, lower quality grades over this very high quality paper. Demand for kraft envelopes will probably also remain roughly stable.

Uncoated Groundwood Paper

This product sector is comprised of uncoated groundwood printing papers containing more than 25% groundwood fiber in their finish, excluding newsprint. Of the 17 U.S. firms that produce uncoated groundwood paper, the 8 major producers are:

Blandin Paper Co.
Boise Cascade Corp.
Crown Zellerbach Corp.
Fraser Paper Ltd.
Georgia-Pacific Corp.
Nekoosa Papers, Inc.
St. Regis Paper Co.
Weyerhaeuser Co.

Uncoated groundwood paper producers lost market share in their major market, the printing and publishing industry, between 1960 and 1975. Since 1976, however, this trend has completely reversed, and uncoated groundwood has begun regaining market share. Reasons for this trend include:

- the printed media advertising boom has increased consumer acceptance of, and consequent demand for, printing on uncoated groundwood papers;
- technology improvements, such as the introduction of super calendered uncoated groundwood production have created higher quality grades whose printing characteristics allow them to compete with freesheet grades;
- new printing technologies, more compatible with groundwood sheets, have helped increase consumer acceptance of uncoated groundwood;
- there is significant price differential between uncoated groundwood grades and competitors; and
- there has been a shift from newsprint to higher quality uncoated groundwood papers for advertising inserts in newspapers.

Thin Papers

These papers include tracing, onionskin, carbonizing, cigarette, Bible and other papers. There are 18 U.S. firms that produce these papers. The major producers are:

Burrows Paper Corp.
Dunn Paper, Div. of Dennison Mfg. Co.
Hammermill Paper Co.
International Paper Co.
James River Corp.
Kimberly-Clark Corp.

Olin Corp.
Port Huron Paper Co.

Thin papers are used with growth cycles reflecting GNP changes. One-time carbonizing paper, a high-growth sector in the early 1970's has slowed its growth rate since 1974. This was caused largely by consumer acceptance of carbonless papers. However, anticipated relative price increases for carbonless papers compared to those for one-time carbonizing papers should stimulate a rise in market share of the latter. Other thin papers (Bible, cigarette, etc.) have exhibited somewhat the same growth behavior relative to the overall economy. Lower prices have helped these grades increase their market share since 1977.

Solid Bleached Bristols

Solid bleached paper is produced for such products as tabulating index, file folder, coated cover bristols, and uncoated bristols (index, printing, and postcard). Of the 18 U.S. firms that produce solid bleached bristols, the 9 major producers are:

Bird & Son, Inc.
Diamond International Corp.
Federal Paper Board Co., Inc.
International Paper Co.
Potlatch Corp.
Scott Paper Co.
Union Camp Corp.
Watervliet Paper Co., Inc.
Wausau Paper Mills Co.

Demand has been essentially static since 1969 primarily because of declining use of tabulating cards as business machines are designed for greater use of tape input/output and larger internal memory banks and with the increasing use of interactive computer systems. The continuation of these trends will lead to declining demand. Demand for other grades, such as tag and file folder, correlates well with GNP. However, the introduction of electronic devices into the office will tend to damper growth in this sector.

Cotton Fibre

Cotton fibre is defined as papers with a furnish containing 25% or more of cotton, cotton rags, cotton wastes, linters, linter pulp, flax or similar fibers. There are 19 U.S. firms that produce cotton fibre. The major producers are:

Consolidated Papers, Inc.
Continental Fibre Co.
Crane & Co.
Hammermill Paper Co.
Kimberly-Clark Corp.

Mead Corp.
Nekoosa Paper Co.
Rising Paper Co.
Simpson Paper Co.
Spaulding Fibre Co.

Cotton fibre papers face competition from chemical wood pulp papers, and their demand varies in response to relative price changes. The long-term trend has been a decline in cotton fibre's market share, due largely to higher costs of cotton fibre production; this trend is expected to continue.

All Other Paper

This is a residual category for all paper products not otherwise classified. There are 18 U.S. firms that produce all other paper. The major producers are:

Appleton Papers Division of NCR
Boise Cascade Corp.
Brown Co.
Deerfield Specialty Papers, Inc.
Kimberly-Clark Corp.
P.H. Glatfelter Co.
Philips Morris Ind. Paper Group
Scott Paper Co.
Sorg Paper Co.
Weyerhaeuser Co.

Lack of available data prevents a discussion of economic and technological trends for this product sector.

Unbleached Kraft Linerboard

Unbleached kraft linerboard is defined as paperboard made from furnish containing not less than 80% wood pulp produced by the kraft process, manufactured for use as facing materials when combined with paperboard for conversion into corrugated or solid fiber boxes. It includes solid unbleached kraft linerboard, both Fourdrinier and Cylinder, mottle white linerboard, and clay coated unbleached kraft linerboard. There are 29 U.S. firms that produce unbleached kraft linerboard. The major producers are:

Container Corp. of America
Continental Forest Industries
Georgia Kraft Co.
International Paper Co.
Nekoosa Papers, Inc.
Owens-Illinois, Inc.
St. Regis Paper Co.
Union Camp Corp.
Weyerhaeuser Co.

Demand for kraft linerboard relates directly to the shipping container requirements of the full spectrum of American industry; thus, it is strongly influenced by the main macroeconomic indicators, including the industrial production index and GNP. The only real competitive threat to shipping containers made from unbleached linerboard and corrugating medium comes from the use of heavy-guage shrink plastic film (film which can be wrapped around a pallet of packages and then shrunk by heating to hold the load securely). The superior cost/performance characteristics of corrugated containers, however, limit shrink film competition to very few applications. Other products have not encroached significantly into linerboard markets.

Bleached Kraft Linerboard

Bleached kraft linerboard is paperboard made from a furnish containing not less than 80% bleached virgin chemical woodpulp. It is manufactured for use as display stands and advertising board and for converting into cigarette and similar type boxes. The 6 U.S. firms that produce bleached kraft linerboard are:

Gilman Paper Co.
International Paper Co.
Longview Fibre Co.
Scott Paper Co.
St. Regis Paper Co.
Temple Eastex, Inc.

Bleached kraft linerboard is a very small sector of the paperboard industry. It is a higher quality linerboard than unbleached. Forecasts are for bleached linerboard to remain at roughly .8% of total linerboard production.

Bleached Foldingboard

Bleached foldingboard is paperboard made from a furnish containing not less than 80% virgin bleached chemical wood pulp and is used for conversion into folding cartons, such as containers for icecream, butter, oleo margarine, bakery products, frozen foods, cosmetics and drugs. Of the 13 U.S. firms that produce bleached foldingboard, the 8 largest are:

Container Corp. of America
Continental Forest Industries
Federal Paper Board Co., Inc.
Gilman Paper Co.
International Paper Co.
Potlatch Corp.
Union Camp Corp.
Weyerhaeuser Co.

Foldingboard is used almost exclusively in the manufacture of folding cartons, of which the three most important bleached kinds are medical, wet food, and beverage packaging. Long-term demand for medical foldingboard has been increasing due to:

- long-term increases in demands for health care and medical products;
- movement toward unit dose packaging by hospitals and retail pharmacies;
- penetration into new market such as disposable sanitary products; and
- an increase in consumption of over the counter drugs.

Wet food packaging cartons face severe competition from plastics films and pouches, especially in the frozen vegetable sector, and from hard thermoplastics in the butter and margarine packaging sectors. Plastic container and flexible packaging pose competition to several bleached foldingboard markets. Also, declining basis weights for board require more square feet of packaging per ton.

Solid Bleached Board

Solid bleached board is defined as paperboard made from a furnish containing not less than 80% virgin bleached chemical wood pulp, for conversion into milk carton, heavyweight cup and round nested food container, plate, dish and tray, and into packaging for moist, liquid, and oily foods, for blister packs, tubes, and other products not classified elsewhere, and for industrial products not classified under bleached bristol and for export. There are 17 U.S. firms that produce solid bleached board. The major producers are:

American Can Co.
Champion International
Container Corp. of America
Georgia-Pacific Corp.
Gulf States Paper Corp.
International Paper Co.
Temple Eastex, Inc.
Westvaco Corp.

The recycled milk carton market ended in 1973 with passage of laws prohibiting use of waste material for milk cartons. As with several other paperboard sectors, virgin fiber milk carton faces severe competition from plastics. The historical milk packaging trend has been from glass to paperboard and now to plastic. Also there is a trend toward sales of larger sizes of milk containers which lower the paperboard requirement per unit of milk. Overall demand for solid bleached milk carton has declined since about 1970.

Two other trends are noteworthy in this sector. One is the major competition from plastics for the drinking cup market. The other is the substitutability of molded pulp products, such as trays, for several solid bleached all other products.

Semi-chemical Corrugating Medium

Semi-chemical corrugating medium is defined as paperboard made from a furnish containing not less than 75% virgin wood pulp, the predominant portion of which is produced by a semi-chemical process, used as the fluting material when combined with paperboard for conversion into corrugated boxes. There are 29 U.S. firms that produce semi-chemical corrugating medium. The major producers are:

Champion International
International Paper Co.
Mead Corp.
Menasha Corp.
Owens-Illinois, Inc.
Packaging Corp. of America
Stone Container Corp.
Weyerhaeuser Co.

Corrugated containers in which semi-chemical corrugating medium is a central ingredient have become established as an essential low-cost packaging material with few substitutes. Demand for corrugated containers is directly related to the shipping container requirements of the full spectrum of American industry; thus, it is strongly influenced by the main macroeconomic indicators including the industrial production index and GNP.

Recycled Linerboard

Recycled linerboard is paperboard manufactured from a combination of recycled fibers from various grades of paper stock and containing less than 80% virgin kraft wood pulp. It is used as facing material when combining paperboard for conversion into corrugated or solid fiber boxes and is often called "test" linerboard. There are 20 U.S. firms that produce recycled linerboard. The major producers are:

Container Corp. of America
Clevepak Corp.
Grief Board Corp.
Inland Container Corp.
Menominee Paper Co., Inc.
Packaging Corp. of America
Sweetwater Paper Board Co.
Whippany Paper Board Co., Inc.

As with unbleached kraft linerboard, recycled linerboard as a key component in paperboard boxes faces an increasingly mature market; production increases and capacity expansions depend more on increases in existing markets than on expansion into new areas. In addition, plastics penetration threatens traditional paperboard box markets. A trend toward recycling paperboard is resulting in increased amounts of recycled pulp in "solid" linerboard production. This will likely continue. Several recent incremental expansions at unbleached kraft linerboard mills have emphasized recycled pulp use, partly because this requires smaller capital investment and pollution control expenditures. (Secondary fiber systems have smaller waste loads per ton of capacity than does virgin fiber.) The recycled pulping process also requires less energy than virgin fiber, but this can be negated partially or wholly by the problems and costs of removing foreign particles and chemicals, such as adhesives.

Recycled Corrugating Medium

Recycled corrugating medium is defined as paperboard produced from a furnish containing less than 75% virgin wood pulp and from a combination of recycled fibers, which is used as the fluting material when combining paperboard for conversion into corrugated boxes and is often called "bogus" medium. The recycled corrugating medium product sector also includes container, shipping and filler board, recycled paperboard used as a filler for solid fiberboard and as a facing for interior packaging products. There are 20 U.S. firms that produce recycled corrugating medium. The major producers are:

Alton Box Board Co.
Container Corp. of America
Cornwall Paper Mills Co.
Inland Container Corp.
Mead Corp.
Newark Boxboard Co.
St. Regis Paper Co.
Whippany Paper Board Co., Inc.

Recycled corrugating medium's economic position is a cross between that of recycled linerboard and semi-chemical corrugating medium. Like recycled linerboard, recycled corrugating medium will benefit from any national paperboard recycling trends. This type of future movement has particular potential due to the relative ease of collecting containerboard for recycling at, for example, supermarkets where a few people can collect large numbers of boxes. Also, low pollution control expenditures for secondary fiber systems add to recycled corrugating medium's future attractiveness.

At the same time, however, demand for corrugating medium will not increase as rapidly in the near future as in the recent past, since the containerboard market is close to mature. Growth in demand for recycled corrugating medium, therefore, is likely to exceed GNP growth, but not by much.

Recycled Foldingboard

Recycled foldingboard is paperboard manufactured from a combination of recycled fibers from various paper stock grades, with bending quality for conversion into folding cartons (including unlined chipboard, kraft lined, white lined, and clay coated) with nonbending specifications for conversion into rigid or set-up boxes (including plain chipboard, newlined, white vat lined). There are 48 U.S. firms that produce recycled foldingboard. The major producers are:

Brown Co.
Champion International
Container Corp. of America
Federal Paper Board Co., Inc.
Newark Boxboard Co.
Packaging Corp. of America
Simkins Industries, Inc.
St. Regis Paper Co.

Recycled foldingboard enjoys few of the advantages over virgin foldingboard that recycled linerboard and corrugated medium have over their virgin products. Foldingboard's large variety of specific end uses do not allow for its easy collection (e.g., at grocery stores) for recycling. Also, many of foldingboard's fastest growing end uses, such as food wrappings or medicinal containers, are markets with strong consumer preferences for cleanliness and brightness, qualities less prevalent in recycled than in virgin foldingboard. Further, the encroachment of plastics into the food and nondurable packaging sector has been particularly important. For all these reasons, the recycled foldingboard product sector has a less promising economic future than other recycled paperboard sectors.

Construction Paper and Board

Construction paper and board is defined as paper and board for use as sheathing paper, felts (roofing felts, floor covering, automotive felts, deadening, industrial, pipe covering, refrigerator), asbestos paper and asbestos filled paper, and flexible wood fiber insulation. This sector also includes insulating board, a fibrous-felted homogeneous panel made by interfelting of the fibers (e.g., interior building board, wallboard, sound deadening board, acoustical tile, exterior sheathing board, roof insulation board, trailer board, etc.), hard pressed board, a vegetable fiber hardboard with a density 31 pounds or over per cubic foot, treated or tempered or not treated or tempered, and wet machine board, including binders board and shoe board (e.g., counter board, heel board, innersole, etc.). Automotive board, chair seat backing, coaster board, luggage, mill board, panel board, table top board are also included. There are 44 U.S. firms that produce construction paper and board. The major producers are:

Bird & Son, Inc.
Celotex Corp.
Certain-Teed Products Corp.
Flintkote Co.
GAF Corp.
Johns-Manville Corp.
Lloyd A. Fry Roofing co.
National Gypsum Co.

Like all building materials, the demand for construction paper subdivides into new construction and replacement (or remodeling) components. The replacement market is a large component because roofing shingles, which require relatively frequent replacement, are the largest end use. Also, floor underlayment and sheathing papers are required for many remodeling projects. Thus, the construction paper and board market does not experience as severe year-to-year fluctuations in demand as do most other commodity construction materials.

There are no significant direct product substitutes for construction paper and board. However, shifts in other construction materials use have had some impacts, such as the substitution for wooden floors of vinyl tile and wall-to-wall carpeting, which reduced the consumption of underlayment paper.

Molded Pulp Products

Molded pulp products are comprised of all kinds of pressed and molded goods from various furnishes. Molded pulp products include egg packages, paperplates, foodtrays, and bottle protectors. The 5 U.S. firms that produce molded pulp products are:

Diamond International Corp.
Formart Containers, Inc.
Keyes Fibre Co.
Owens-Illinois, Inc.
Packaging Corp. of America

Molded pulp products can be made into a wide variety of shapes and sizes, and have a high resistance to liquids. This property is particularly important in meat packaging, where excess juices ordinarily disintegrate a package.

In the late 1960s, molded pulp products began to lose their share of packaging markets to competitive plastic products. Producers are more than compensating for these losses now, however, by expanding into disposable tableware.

All Other Paperboard

All other paperboard is defined as the residual category for all unbleached kraft paperboard (including unbleached kraft foldingboard), all semi-chemical paperboard, and all recycled paperboard for end uses not elsewhere classified. It includes matchbook board, gypsum wallboard facing, recycled paperboard manufactured for use as a liner on gypsum board, and paperboard for uses such as tube, can drum, file folder, tag, etc. There are 38 U.S. firms that produce all other paperboard. The major producers are:

Celotex Corp.
Georgia Kraft Co.

Georgia-Pacific Corp.
National Gypsum Co.
Olin Kraft, Inc.
Packaging Corp. of America
Sonoco Products Co.
U.S. Gypsum Co.

The most important paperboard product included in all other paperboard is gypsum wall board facing, which is the liner material used to make gypsum wallboard. Gypsum wallboard (which is made exclusively with a recycled paperboard liner material) is a well-entrenched construction product used for both new construction and remodeling. As a result, its demand does not fluctuate as sharply as the building cycle. It does face substitution by a variety of other interior wall panelling materials, but this trend has had relatively minor impact thus far.

The next most important product is unbleached foldingboard. Recent technology changes have allowed the production of lighter weight foldingboard. Foldingboard is used almost exclusively in the manufacture of folding cartons. The chief use of unbleached kraft folding cartons is for beverage carriers. Unbleached kraft foldingboard is losing market share here due to the beverage industry's shift toward larger glass containers and an increased proportion of canned (as opposed to bottled) beer. Also, the trend toward plastic beverage packagings rather than paperboard cartons hurts the unbleached kraft foldingboard product sector. However, penetration into oth[illegible] end-use markets will more than offset any share loss in beverage car[illegible].

Tube, can, and drum stock is a smaller volume product. It consists of paperboard that is wound into spiral cans that range from small orange juice cans to large drums for commodities such as chemicals. Unbleached kraft paper and paperboard compete strongly in this market.

Plastics have not had an important substitution impact in the major markets of all other paperboard, except unbleached kraft foldingboard.

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SECTION 4

PULPING OPERATIONS ANALYSIS

In this section, the operating characteristics of the variety of manufacturing processes, operations, chemicals and equipment used in each study area for the manufacture of pulp are described. For the analysis of each study area, a process description, flow diagram, illustrations and appropriate tables present general information to provide a context for the evaluation of information presented in other parts of this report.

The particular processes that are used depend mainly on the type of paper product desired and the type of wood or material used in pulping operations. Pulpwood preparation, which is treated as a separate study area, involves operations which may vary according to the type of pulp process. The various pulping processes involve chemical recovery and bleaching operations which also vary somewhat according to the pulping process used. Although chemical recovery operations do not directly lead to manufactured paper products, pulping operations could not proceed in a cost effective manner without them. Bleaching operations, which have many characteristics common throughout each study area, are discussed in this section in the context of kraft pulping. For the other pulping study areas involving bleaching, references are often made to operations in the kraft discussion.

The environmental release of conventional, nonconventional, toxic and priority chemical pollutants occurring in the pulping study areas is also presented in this section. The conventional pollutant parameters discussed in this section are presented in terms of effluent characteristics descriptions (including water usage) and are based on a review of pertinent data contained in the literature (1,2,3,4,5). After review of this literature and an evaluation of related field sampling data, the following waste water parameters were identified for the presentation of effluent characteristics and conventional pollutants:

- Water Usage
- Biological Oxygen Demand (BOD5)*
- Total Suspended Solids (TSS)
- pH

The discussion of effluent characteristics is presented to describe the ranges and concentrations of the occurrences of conventional pollutants in each study area and is intended to illustrate the relative and qualitative relationship between BOD, TSS and pH values and the occurrences of associated waste chemicals and materials.

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*Five-day BOD-normally measures only 60 to 80% of the carbonaceous biochemical oxygen demand of the sample, and has been determined from previous studies as a reasonable parameter for the purposes of the following discussion.

Discussion of other nonconventional, toxic and priority pollutants is also presented, and is based on data obtained from a previous study designed to verify and quantify the presence of significant pollutant chemicals in pulp, paper and paperboard industry discharges (2).

The effectiveness of external waste treatment to reduce the final concentrations of these chemicals is also presented. These treatment technologies are discussed in greater detail in Appendix C.

Materials which may contribute to the BOD include: carbonaceous organic materials usable as a food source by aerobic organisms; oxidizable nitrogen derived from nitrites, ammonia and organic nitrogen compounds which serve as food for specific bacteria; and certain chemically oxidizable materials such as ferrous iron, sulfides and sulfites, which will react with dissolved oxygen or are metabolized by bacteria. In most industrial and municipal waste waters, the BOD derives principally from organic materials and from ammonia (which is itself derived from animal or vegetable matter). Compounds contributing to this total organic waste load found in pulp and paper mill wastes incude terpenes, resin acids, fatty acids, phenols, formic acid, acetic acid, saccharinic acids and other small organic acids. Biological treatment systems discussed in this section and in Appendix C, are very successful in eliminating several of the above compounds from "end of the pipe" waste waters. Resin acids, fatty acids, terpenes, hydrocarbons, and phenols have been found to be reduced to the same extent as the overall BOD removal efficiency (3).

Suspended solids include both organic and inorganic materials. The inorganic components discharged by pulp and paper mills include sand, silt, clay and other papermaking additives. The organic fraction includes such materials as fiber and other wood components such as lignin, tannins, and sugars. These solids may settle out rapidly; bottom deposits are often a mixture of both organic and inorganic solids. Solids may be suspended in water for a time, and then settle to the bed of a stream or lake. These solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Although not a specific pollutant, pH describes the acidity and alkalinity of the waste water stream. Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and plumbing fixtures; such corrosion can add constituents to water such as iron, copper, zinc, cadmium, and lead. Low pH waters not only tend to dissolve metals from structures and fixtures but also tend to redissolve or leach metals from sludges and bottom sediments. The hydrogen ion concentration can affect the "taste" of the water; at a low pH, water tastes "sour".

Extremes of pH or rapid pH changes can increase the relative toxicity of many pollutant chemicals. For example, metallocyanide complexes can increase a thousand fold in toxicity with a drop in pH of 1.5 units. Similarly, the toxicity of ammonia is a function of pH where excess alkalinity, as exhibited in a high pH value may make water detrimental to most natural organic materials and toxic to living organisms. Alkalinity is commonly caused by the presence of carbonates, bicarbonates, hydroxides and to a lesser extent by borates, silicates, phosphates and organic substances. Ammonia is more lethal with the higher pH. The lacrimal fluid of the eye has a pH of approximately 7.0; a deviation of 0.1 pH from the norm may result in appreciable eye irritation and severe pain.

In addition to these conventional pollutants, this section presents a review of nonconventional, priority and toxic pollutant data obtained during a previous EPA study designed to investigate the presence of pertinent chemicals in pulp, paper and paperboard industry discharges (1). In that study, a screening and verification program was undertaken to obtain data on 42 organic priority pollutants, 6 metals, cyanide, 14 nonconventional organics (xylene, 4 resins, 3 fatty acids and 6 bleach plant derivatives), color, ammonia and COD. A list of these chemical derivatives (color, ammonia and COD) is presented in Table 5. In the study, surveys were conducted to provide a thorough examination of the possible sources of these pollutants, the quantity discharge to "end of the pipe" treatment systems and the relative efficiency of the treatment system for removing specific compounds. In this section, a summary of the pollutant analysis results for these compounds is presented. This summary includes tables illustrating the ranges of concentrations and the average concentration of specific compounds at raw waste and final effluent sampling points at those mills where the compounds were detected during a short term survey (consisting of 24 hour and 72 hour composite samples and grab samples).

In addition to the screening and verification program, a long term sampling program was conducted during the same study to investigate the variability and treatability of certain toxic and nonconventional pollutants discharged throughout the industry (1). A list of the pollutant parameters selected for analysis during the long term sampling program is presented in Table 6. Since the long term sampling program was limited due to budgetary concerns, only two mills were selected for sampling. This selection was based on a review of previous data showing that bleached kraft facilities could have detectable levels of all the pollutants of concern (except PCB's) in their waste waters. A further review showed that PCB's, chloroform and the chlorophenolics could be found in waste waters discharged from deinking mills where bleaching is employed. One mill from each subcategory was selected to provide full coverage of the toxic and nonconventional pollutants of concern.

PULPWOOD PREPARATION (STUDY AREA 1)

Pulpwood is delivered to the mill by water in rafts or barges, or by land in trucks, rail cars, and hydraulic or pneumatic piping. Wood is delivered in the form of rough or bark-free logs (roundwood). Chips are made from whole trees (at the forest site) or debarked logs, or sawdust (derived from building products, sawmills, or other sources). Roundwood is delivered in lengths of 4 to 5 feet, in longer specific lengths, and in whole-tree lengths (6).

Table 5 PRIORITY AND NONCONVENTIONAL POLLUTANTS ANALYZED DURING SAMPLING OF PULP, PAPER AND PAPERBOARD EFFLUENT STREAMS (1)

Priority Pollutants

benzene
chlorobenzene
1,2-dichloroethane
1,1,1-trichloroethane
1,1-dichloroethane
1,1,2,2-tetrachloroethane
trichlorophenol*
chloroform
2,4-dichlorophenol
ethylbenzene
fluoranthene
methylene chloride
dichlorobromomethane
trichlorofluoromethane
chlorodibromomethane
isophorone
naphthalene
phenol
bis(2-ethylhexyl) phthalate
di-n-butyl phthalate
bromoform
pentachlorophenol
carbon tetrachloride
2-chlorophenol
2,4-dinitrophenol

di-n-octyl phthalate
diethyl phthalate
chrysene
anthracene/phenathrene
tetrachloroethylene
toluene
trichloroethylene
chromium
zinc
nickel
copper
lead
mercury
PCB-1242 - wastepaper user only
PCB-1254 - wastepaper users only
PCB-1221 - wastepaper users only
PCB-1232 - wastepaper users only
PCB-1248 - wastepaper users only
PCB-1260 - wastepaper users only
PCB-1016 - wastepaper users only
cyanide - wastepaper users only
pyrene
acenaphthylene
parachlorometa cresol
butyl benzyl phthalate

Nonconventional Pollutants

oleic acid
linoleic acid
linolenic acid
pimaric acid
isopimaric acid
dehydroabietic acid
abietic acid
color

3,4,5-trichloroguaiacol
tetrachloroguaiacol
monochlorodehydroabietic acid
dichlorodehydroabietic acid
9,10-epoxystearic acid
9,10-dichlorostearic acid
xylenes
ammonia

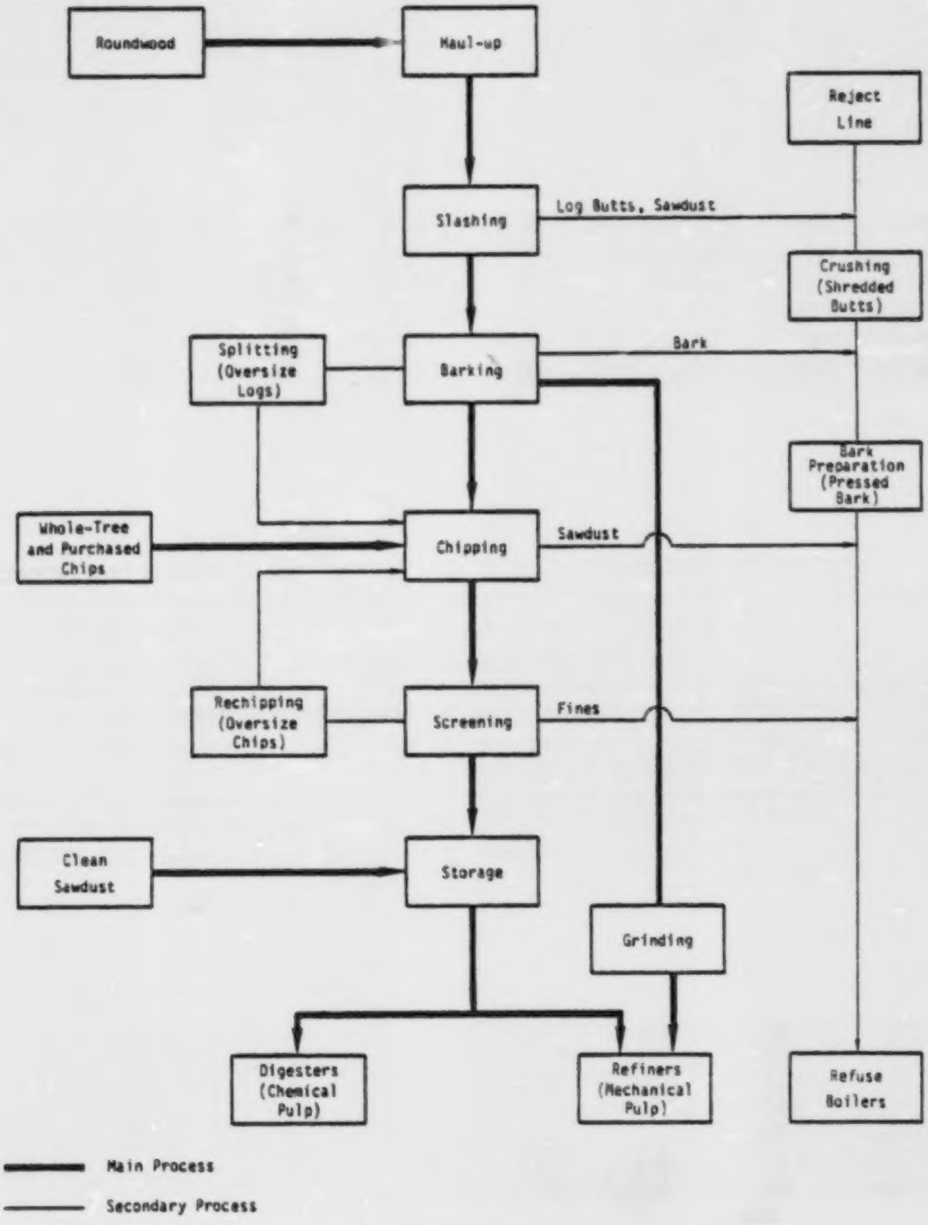
*Includes 2,4,5 and 2,4,6 - trichlorophenol

Table 6 TOXIC AND NONCONVENTIONAL POLLUTANTS SELECTED FOR ANALYSIS DURING THE LONG-TERM SAMPLING PROGRAM (1)

Toxic Pollutants	Nonconventional Pollutants
Chlorinated Phenolics:	Chlorinated Phenolics:
2,4-dichlorophenol	4,5-dichloroguaiacol
trichlorophenol[1]	3,4,5-trichloroguaiacol
pentachlorophenol	4,5,6-trichloroguaiacol
	tetrachloroguaiacol
Halomethane:	Unsaturated Fatty Acids:
chloroform	oleic acid
	linoleic acid
	linolenic acid
Polychlorinated Biphenyls (PCB)[2]:	Unsaturated Fatty Acid Derivatives:
PCB-1016	9,10-epoxystearic acid
PCB-1221	9,10-dichlorostearic acid
PCB-1232	
PCB-1242	Resin Acids:
PCB-1248	abietic acid
PCB-1254	dehydroabietic acid
PCB-1260	isopimaric acid
	levopimaric acid
	neoabietic acid
	palustric acid
	pimaric acid
	sandaracopimaric acid
	Chlorinated Resin Acids:
	monochlorodehydroabietic acid
	dichlorodehydroabietic acid
	Ethers:
	dimethyl sulfide
	dimethyl disulfide

[1] Includes 2,4,5 and 2,4,6-trichlorophenol.
[2] Analyzed only at deink mill.

The sequence of woodyard operations is shown in Figure 2. Although most of these operations are performed in the woodyard of a pulp mill, newer techniques allow trees to be delimbed, slashed into logs 4 to 8 feet long, and chipped at the forest site (7). In the woodyard, logs are removed from a pond or river holding area by a haul-up apparatus. This apparatus consists of an inclined causeway fitted with water circulators and chain conveyors that draw logs from the water and move them up the causeway at a speed of 60 to 100 ft/min (6). A walkway is provided at the bottom of the haul-up for operator use in controlling log flow. Cranes are used to unload wood from rail cars and trucks and to load logs from storage piles on the ground into flumes or conveyors for further processing.



Roundwood
Haul-up
Reject Line
Slashing
Log Butts, Sawdust
Crushing (Shredded Butts)
Splitting (Oversize Logs)
Barking
Bark
Bark Preparation (Pressed Bark)
Whole-Tree and Purchased Chips
Chipping
Sawdust
Rechipping (Oversize Chips)
Screening
Fines
Clean Sawdust
Storage
Grinding
Digesters (Chemical Pulp)
Refiners (Mechanical Pulp)
Refuse Boilers
Main Process
Secondary Process

Figure 2 Flow Diagram for Pulpwood Preparation

Logs are led to a slasher table or deck where they are cut into lengths up to 8 feet by several circular table saws at various locations spanning the width of the deck and offset from each other by about 6 feet. The logs are conveyed across the slasher deck by endless feed chains. The deck has openings at each saw for the discharge of sawdust and butts (short ends cut from the logs) to a belt conveyor for delivery to crushers and to the refuse boilers used for steam generation. The saws can be removed for maintenance without disturbing the feed chains. Wire-mesh safety guards are usually placed around the saws. The slashed logs are discharged onto a conveyor for transport to bark removal operations or storage piles.

Bark has little use in pulping operations, since it cannot be used commercially for fiber and complicates pulp cleaning, digesting, and refining operations. Consequently, bark is removed from roundwood before the wood is chipped or ground into pulp. This process is termed "barking" or "debarking". Logs are debarked either by jets of high-pressure water in a hydraulic barker (used mainly in the Pacific Northwest), by the abrading action of logs tumbling or rolling against each other (drum barker and bag barker) or against stationary radial arms of a rotating ring (ring barker). Figure 3 illustrates a typical wet type barking drum. The wet inlet section is of solid steel plate, while the open section on the right has slots in the drum to let the bark fall out. For dry barking, the drum will have the open section full length. Debarking may also occur by stripping bark from wood by knives that are mounted radially on the face of a rotating disc (knife barker). In knife barkers and cutterhead barkers, where bark is removed by the milling action of a cylindrical cutterhead, logs are passed through singly. Some knife barkers require that one end of the log be held by an operator while the other end is debarked by rotating the log against the disc.

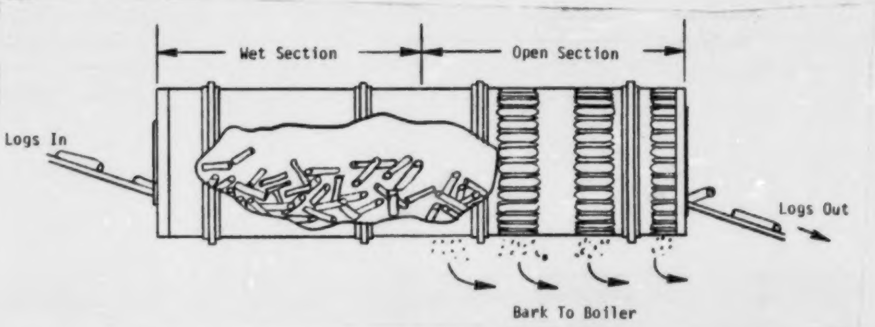


Figure 3 Typical Wet Type Barking Drum

Drum barkers are large open-ended cylindrical sections welded together that range from 8 to 16 feet in diameter and from 22.5 to 75.0 feet in length (6). The cylinder rotates on an axis, so that logs entering one end will tumble toward the other end. Bark falls through the horizontally-aligned staves of each cylindrical section onto conveyors or is washed away by water if the cylindrical shell is solid and partially immersed in water. Water sprays, with an output of up to 400 gallons per minute at a temperature of 38° to 93°C, may be used at either or both ends of a barking drum to increase efficiency. Hydraulic barkers used high-pressure (800 to 1,600 psi) jets of water for bark removal. Warm-water ponds are also used to soak frozen logs. Bark that has been removed is compressed by hydraulic presses and is conveyed to refuse boilers.

Logs are inspected, returned to barkers if necessary, and cleaned by water showers. Logs that will not fit in most chipper spouts and logs with gum streaks are conveyed to splitters, which quarter them in a single stroke. The logs are split when driven through a frame having stationary horizontal and vertical axes. A hydraulic ram drives the log through the frame with a splitting force of about 50 tons. Chippers with large feed spouts are eliminating the need for splitters. Barked and cleaned logs that will be ground and refined in mechanical pulping operations are stored or conveyed directly to grindstones.

Roundwood sticks that have been slashed, debarked, split, and cleaned are conveyed to the chipper, which reduces the wood to chips that will allow efficient penetration of chemicals used for digestion of lignin (7). Pulp chips are also used without chemical treatment to produce refiner mechanical pulp. Chippers are large rotating discs that contain knives radiating from the hub of the disc like spokes on a wheel, as shown in Figure 4. There are usually 12 knives to a disc (the number can vary from 3 to 16) which may have a diameter as large as 175 inches for whole-log chipping (8). Usually, logs are fed through a spout at about a 45° angle to reduce the log to chips 0.65 to 0.75 inches long. Other chippers, such as the rotating drum chipper and the horizontal parallel chipper, cut logs parallel to the grain of the wood. The conical disc chipper cuts logs against the wood grain at about a 25° angle (6).

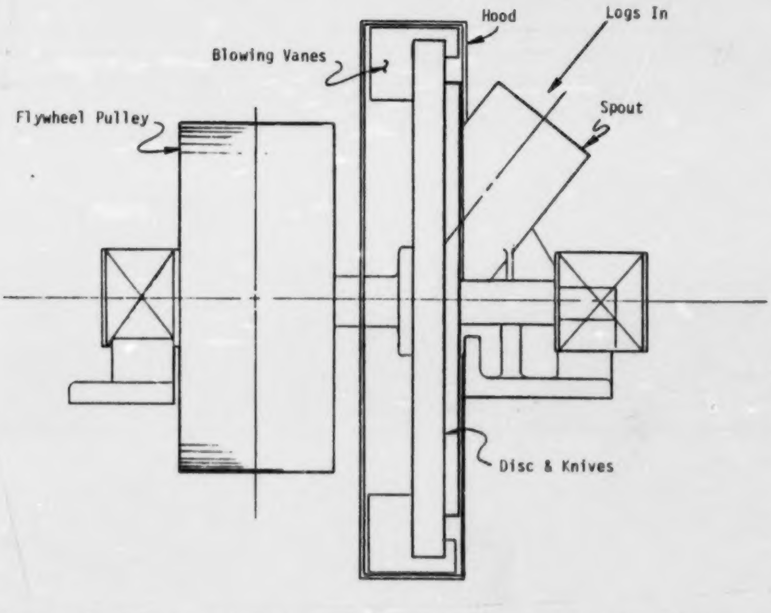


Figure 4 Cross Section Through Typical Blowing Chipper

Material emerging from the chipper includes wood slivers, oversize chips, fines (sawdust, fine bark, and chips under 0.25 inches long), and acceptable chips. To separate this material, a screening system of vibrating or gyrating trays, and rotary drum shakers isolates oversize chips from the fines. Oversize chips are rechipped and screened, and fines are discharged to a refuse conveyor. Accepted chips may be stored in chip piles, chip bins, or silos. Bins or silos are also used to store clean sawdust, which is purchased from other sources for use in the pulp mill.

Since the nature of process control during pulpwood preparation varies according to the pulping process, such controls are presented in the other study areas.

During pulpwood preparation, water usage and waste water characteristics vary according to the type of pulp mill that is using the wood (i.e., mechanical, chemical pulping). At mills where wood pulp is manufactured on site, water is utilized for log transport, log and chip washing/thawing, barking operations and for storage of logs in rivers or ponds. The range of effluent characteristics for the combined waste water discharge streams of these operations is shown in Table 7. These data represent the range and mean of final waste water characteristics discharged from pulpwood preparation for all types of mills.

Table 7 EFFLUENT CHARACTERISTICS OF PULPWOOD PREPARATION

	pH	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Range	6.5-8.5	2-10	1.9-40	4.1-42
Mean	7	3	9	14

Flume waste water overflow, which is reusable, contains various amounts of bark fines and silt. After the flume water has been used for a certain amount of time, the water is run through a grit removal and screening system before it is discharged. In Table 8, the raw waste characteristics for this component of pulpwood preparation are presented for various types of mills. Also shown in Table 8 are the ranges of effluent characteristics at various types of mills for log and chip washing/thawing operations, and hydraulic and wet drum debarking operations.

There are no available data on particulate and other air emissions from pulpwood prepartion areas. Although airborne material of this type is not a problem in wet operations, there is a potential for some airborne emissions in dry barking systems.

Table 8 EFFLUENT CHARACTERISTICS OF MAJOR COMPONENTS OF PULPWOOD PREPARATION

		BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Flume Waste Water				
Groundwood		0.38	6.35	3.2
Kraft, Soda, Sulfite (Papergrade)		0.76	12.7	6.4
Kraft, Soda, Sulfite (Dissolving)		1.0	17.5	8.8
Log/Chip Washing (All Mill Types)		0.2-4.0	2.5-27.5	0.4-6.3
Wet Drum Debarking				
Groundwood	(Range)	1.3-4.3		3.8-26.3
	(Mean)	2.6		14.2
Kraft, Soda, Sulfite - Papergrade	(Range)	2.6-8.6		7.6-52.6
	(Mean)	5.2		28.4
Kraft, Soda, Sulfite - Dissolving	(Range)	3.6-11.8		10.5-72.3
	(Mean)	7.2		39.1
Hydraulic Debarking				
Groundwood	(Range)	0.3-11.8		3.8-54.6
	(Mean)	2.2		15.4
Kraft, Soda, Sulfite - Papergrade	(Range)	0.6-23.6		7.6-109.2
	(Mean)	4.4		30.8
Kraft, Soda, Sulfite - Dissolving	(Range)	0.8-32.5		10.8-150.2
	(Mean)	6.1		42.4

KRAFT PULP PROCESSING (STUDY AREA 2)

The kraft chemical wood pulping process involves the extraction of cellulose fibers, or "wood pulp", from the wood by dissolving and removing the lignin that binds the cellulose fibers together. The kraft method can be used with almost any wood species, requires a relatively short time period to complete delignification, does not degrade the valuable cellulose and hemicelluloses in the wood as badly as other chemical pulping processes and permits recovery of a high percentage of the cooking chemicals.

Figure 5 is a flow sheet of typical integrated kraft pulp mill operations. In this diagram, process controls used to improve or maintain production efficiency and/or reduce waste loadings and effluent flow, are numbered. These controls, which are also presented in Table 9, are discussed in Appendix B.

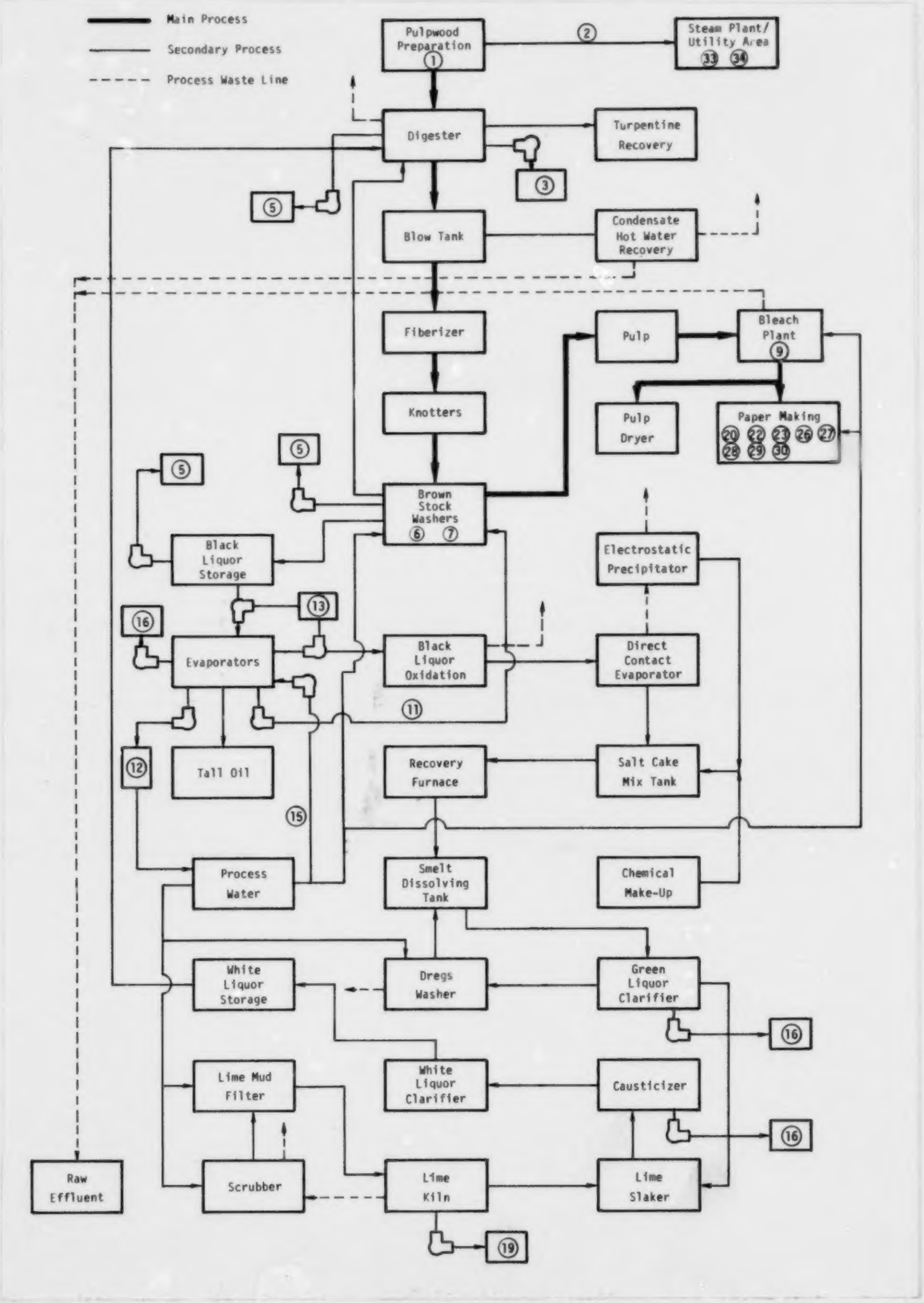


Figure 5 Integrated Kraft Pulp Mill Flow Diagram

Table 9 KRAFT PROCESS CONTROL MEASURES

Process Component	Control Technology Description	Subcategory				
		Dissolving	Market	BCT	Fine	Unbleached
Pulpwood Preparation	1 Close up or dry woodyard and barking operation				●	●
	2 Segregate cooling water	●	●	●	●	●
Digester	3 Reuse blow condensates	●	●	●	●	●
Digester, Liquor Storage, Brown Stock Washers	5 Spill collection	●	●	●	●	
Pulp Washing Lines	6 Installation of 4th stage washer	●	●	●	●	●
Decker	7 Decker filtrate reuse					●
Bleach Plant	9 Countercurrent or jumpstage washing		●	●	●	
Evaporator/Recovery Area	11 Recycle of condensates					●
	12 Replace barometric condensor	●				
	13 Install boil out tank	●	●	●	●	●
	15 Segregate cooling water		●			●
Liquor Storage, Causticizing Area	16 Spill collection	●	●	●	●	
Lime Kiln Area	19 Spill collection	●	●	●	●	
Papermaking	20 Paper machines/bleached pulp spill collection	●	●	●	●	
	Color plant spill collection				●	
	23 White water use for vacuum pump sealing	●		●	●	
	26 Recycle of press water	●				●
	27 Reuse of vacuum pump water				●	●
	28 Broke storage					●
	29 Installation of wet lap machine				●	
	30 Segregate cooling water					●
Steam Plant/Utility Areas	33 Segregate cooling water	●	●	●	●	●
	34 Lagoon for boiler blowdown and backwash waters	●	●	●	●	

After pulpwood logs are debarked and chipped, the chips are fed into a continuous digester system. In Figure 6, an example of such a system is shown where presteaming and impregnation are done in a low-pressure vertical vessel separate from the digester. Chips are fed countercurrent to a fresh chemical stream (called white liquor) containing about 21% active chemicals, of which three quarters is sodium hydroxide and one quarter is sodium sulfide in water solution. These two process chemicals amount to the following approximate usage requirements relative to the pulp product (9):

Sodium Hydroxide - 177 kg/kkg
Sodium Sulfide - 27 kg/kkg

The digester is held at 7.03 to 9.49 kg/cm^2 (100.0 to 135.0 psi) and 170° to 175°C. Time required for the cooking cycle is from one hour for unbleached brown pulp to as much as 5 or 6 hours for pulps that are to be bleached (10). The cooking process causes formation of malodorous sulfide gases, such as hydrogen sulfide, methyl mercaptan, and dimethyl sulfide. Venting of these gases gives a kraft mill its typical sour odor.

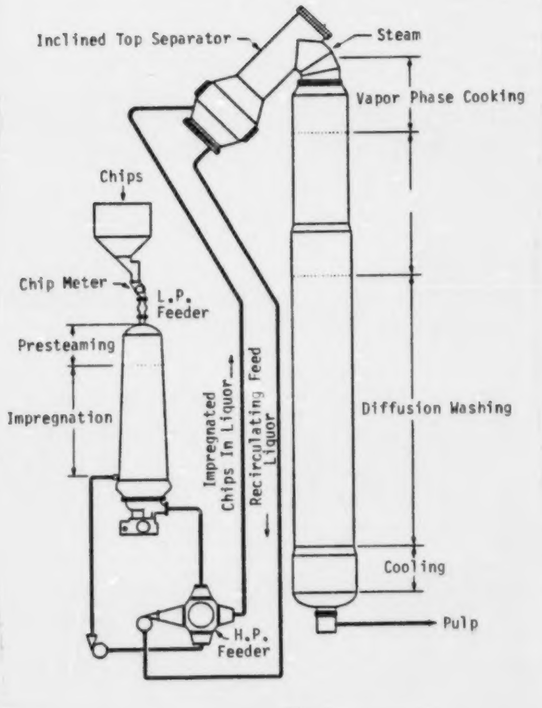
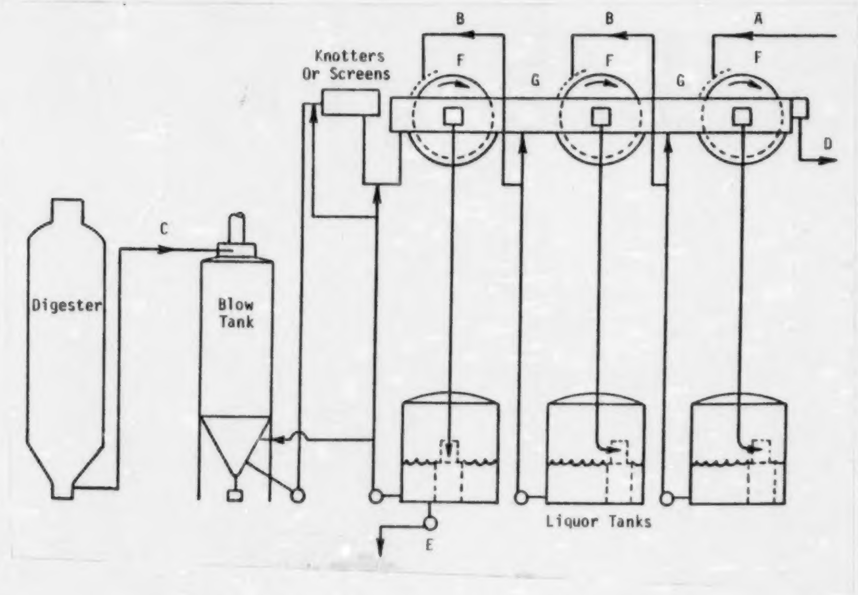


Figure 6 Continuous Digester System

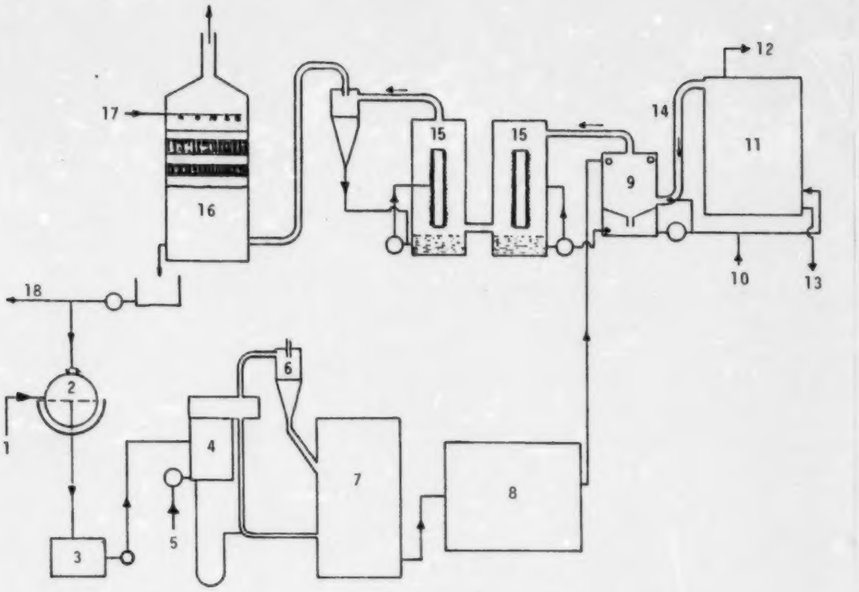
The contents of the digester exit through a "blow tank", where steam and noncondensibles are flashed-off, and cooked chips are sent to a brownstock washing operation that separates the pulp from the spent cooking liquor, now called "black liquor". A typical brown stock operation is made up of a series of rotary-drum vacuum filters with intermediate repulpers for redilution and agitation of the pulp sheet. Almost all the systems in the United States use a single liquor displacement on each washer, as shown in Figure 7. The pulp passes on for further refining and possibly bleaching before it is pressed, dried, and sold as pulp or made into paper or other products.



A. Water added in final stage; B. water flowing counter-currently to middle and then first stage.; C. blown pulp entering system.; D. Washed pulp existing system; E. water from first stage to evaporator; F. filter; G. repulpers

Figure 7 Brown Stock Washer Operation

Satisfactory economics for the kraft process require efficient recovery of sodium and sulfur values from the black liquor, as depicted in Figure 8. The organic sulfides, also called "reduced sulfur" or "mercaptans", are often oxidized in the black liquor oxidation system as an air pollution control measure to render them less volatile and thus diminish loss when a direct contact evaporator is used in subsequent steps. The black liquor is then concentrated to 50% solids in a multiple-effect evaporator and pumped to the recovery furnace.



1. Pulp from digester; 2. brown stock washers; 3.storage tank; 4. oxidation tower; 5. air supply; 6. cyclones; 7. foam tank; 8. muliple effect evaporation plant; 9. cyclonic evaporator; 10. salt cake addition; 11. recovery furnace; 12. steam to process; 13. smelt to causticizing; 14. flue gas; 15. deluge towers; 16. condensing tower; 17. cooling water; 18. hot water to bleach plant etc.

Figure 8 Black Liquor Oxidation and Chemicals Recovery System

At the recovery furnace the black liquor is concentrated to 70% combustible solids, in the case of direct contact evaporation, by countercurrent flow against hot combustion gases from the furnace. If good oxidation is obtained upstream, this unit will emit only small quantities of volatile reduced sulfur compounds (11).

The black liquor concentrate is sprayed into the recovery furnace, where the carbon from the wood is burned, the remaining water is evaporated, and the sodium is changed to molten sodium carbonate or sodium sulfide. These molten salts, or "smelt", are redissolved in water to form "green liquor", then are clarified and causticized with lime, as illustrated in Figure 9.

The calcium carbonate resulting from causticizing is filtered from the "white liquor" and is passed on an oil- or gas-fired kiln. Entering the kiln at 35% moisture, the calcium carbonate is dried and then decomposes at about 1300°C to calcium oxide and carbon dioxide (11). The "white liquor" is recycled to the digester.

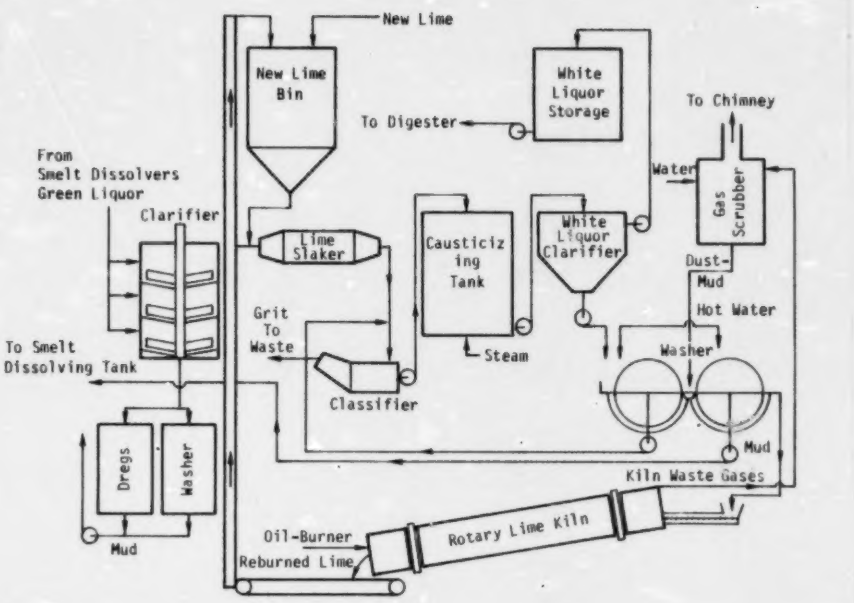


Figure 9 Flow Sheet of a Typical Causticizing Plant

The lime kiln is essential to the system of recycling caustic soda for reuse in digestion. It receives lime "mud" or calcium carbonate and burns it to quicklime (calcium oxide), which, after being slaked, is allowed to react with sodium carbonate in the green liquor to make the caustic soda.

Most lime kilns used by pulp mills are of the rotary type and are constructed of refractory-lined steel. They are inclined, and the lime mud is fed into the elevated end, where it contacts the counterflow of combustion gases from an oil- or gas-fired burner located at the opposite end. As it moves down the inclined kiln, the mud dries, agglomerates into pellets, and finally is calcined into calcium oxide in the hot zone of the kiln. The fresh, hot lime pellets are discharged at the lower end of the kiln and usually are slaked immediately (11).

The lime kiln has several major limitations. It is not efficient in the use of heat; the burnt lime product may vary widely in its subsequent reactivity; and, unless the sodium content of the mud is kept at 0.24% or higher, large loose balls or rings of lime adhere to the inner surface of the kiln and cause stoppages. Efforts have been made to improve the energy efficiency, the reactivity of the lime product, and the operability of the unit by flash-drying the mud ahead of the kiln or by calcining it in a fluid-bed unit in which time-temperature relationships can be controlled closely. Flash-dried mud enters the kiln about 10% moisture. Fluid-bed calciners are in limited use, but their production rates are relatively low, about 20 to 140 mg/day (11). Another development, the use of oxygen to boost kiln output, should decrease the amount of dust carryover per ton of burnt lime production, because it is claimed that lime production increases 25% in a kiln retrofitted for oxygen enrichment. The fuel requirements per increased ton of lime output are about half that required with air alone. Advantages are reduced fuel requirement and reduced gas volume per ton or burnt lime and the attendant reduction of emissions (11).

Kraft pulp mills use process generated steam at a rate of about 5000 kg/kkg of air-dried pulp (12). Before 1960 nearly all of this steam was made at the mill in conventional oil-, gas-, or coal-fired boilers. Wood waste materials, including bark, shavings, sander dust, log yard cleanup, and sawdust (often called "hogged fuel"), were burned in a tepee burner, which gave no heat recovery, had no combustion controls, and emitted large amounts of particulate. By 1973, 88 of 273 mills had at least one power boiler that could burn wood bark (11).

Bark is difficult to burn. Depending on its source, it may contain a large percentage of ash and abrasive sand and as much as 50% water. Bark requires a higher temperature than conventional fuels for good combustion; if it is charged wet, it must remain in the combustion zone long enough for the water and volatiles to boil off before it ignites.

Bark char is very light, about 1/6 the weight of water. It occurs as round, flat flakes, which have a large surface to mass ratio and readily becomes entrained with the combustion gases (13). Recent theoretical studies indicate that at normal flue gas velocities, char of certain particle sizes does not burn out in a conventional furnace and is always carried over (14).

In the chemical recovery process, black liquor of 40% to 55% solids content from the multiple-effect evaporators is concentrated to as high as 70% solids in a direct-contact evaporator heated by recovery furnace flue gas. The direct-contact evaporator may be a cyclonic or venturi-type liquid-gas contactor, or it may be a cascade evaporator. Depending on the pH and temperature of the black liquor, this contactor can remove appreciable quantities of residual SO_2 from the flue gas (11).

The black liquor concentrate is sprayed into the combustion zone of the furnace, where the organic materials burn. The chemicals, chiefly sodium salts, melt and are accumulated on a shallow hearth at the base of the furnace. The molten salts, or smelt, are subsequently dissolved in water to form green liquor, which is causticized to white liquor and recycled to a digester. The recovery furnace in a large, modern kraft mill can supply a major fraction of the process steam needed.

Bleaching is ordinarily performed in a number of stages. This is done to preserve the strength of the pulp by avoiding excessively rigorous chemical treatment and to control consistency and temperature in accordance with the demands of the particular treatment applied. In Figure 10, an example of a four-stage bleaching flow diagram is presented. Each stage consists of a reaction tower in which the pulp is retained in contact with a particular chemical agent for the optimum period of time. It is then washed on vacuum washers (see Figure 11) or diffusers and discharged to the next stage.

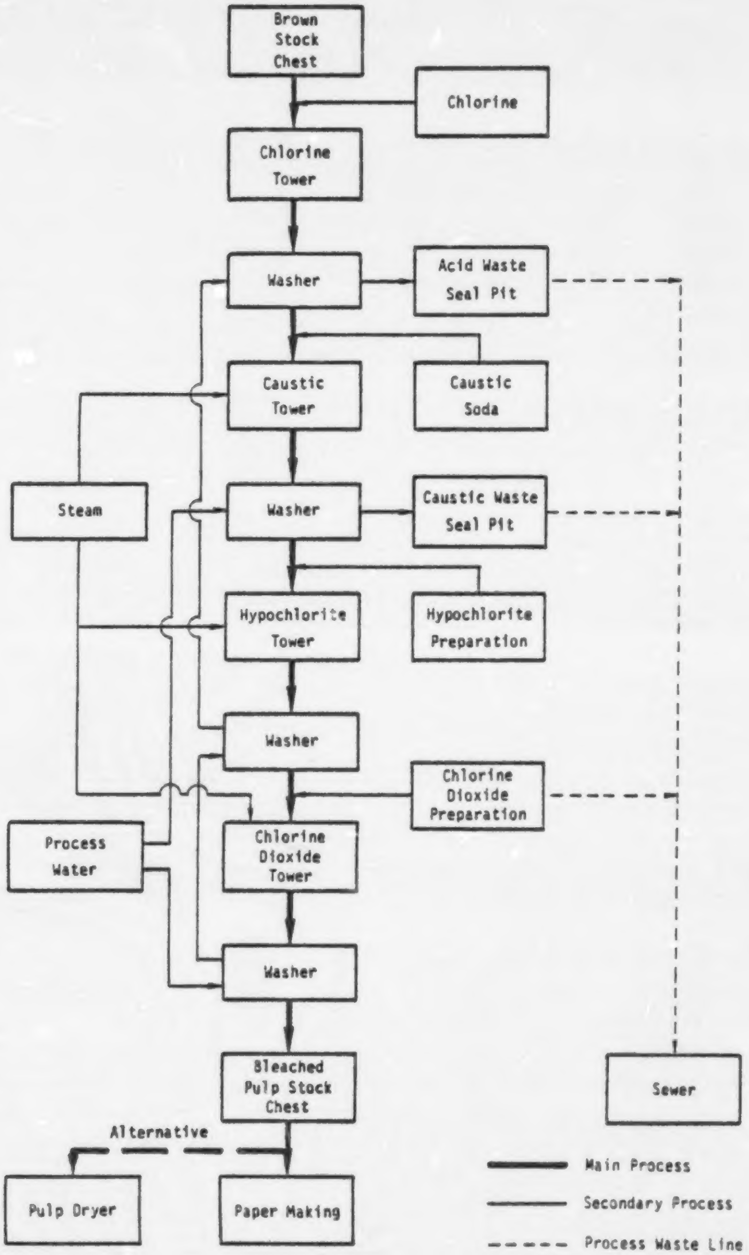


Figure 10 Four-Stage Kraft Pulp Bleach Plant Process Flow Diagram

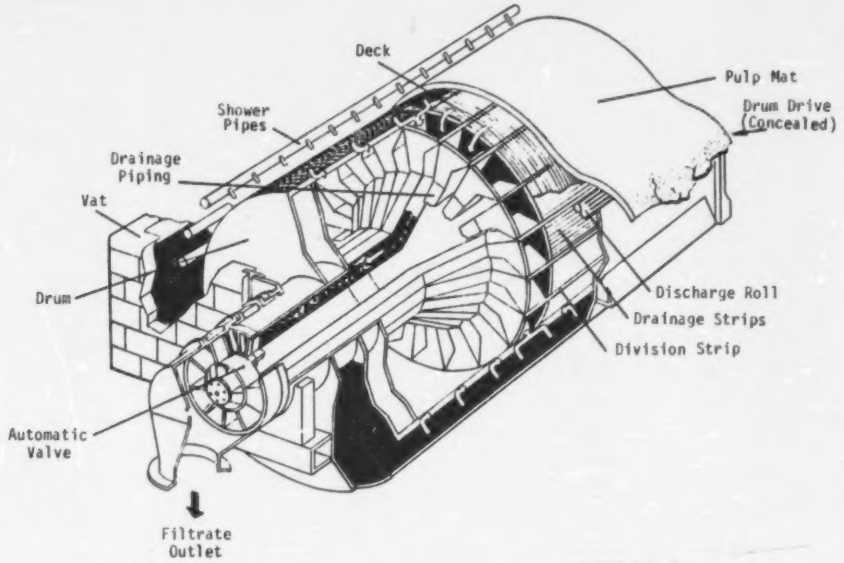


Figure 11 Principle of Operation of the Vacuum Washer

In the washing stage, washing is accomplished by diffusion and displacement. Pulp from a bleach tower is diluted to 0.8 to 1.25% consistency with filtrate from the washer, and it is pumped to the feedbox. Filtrate flows through the screen on the drum, leaving a mat or sheet of pulp one-half to one inch thick on the surface. As the drum rotates, the sheet emerges from the slurry on the rising side and dewaters further to 10 to 16% consistency.

Consistency in the reactors generally ranges from 3.5% to 12% and temperatures range from ambient in the chlorination stage, to 60°C in extraction stages, 35°C in hypochlorite stages, and 82.2°C in chlorine dioxide treatment (15).

The chemicals most commonly employed for bleaching chemical pulps are chlorine, calcium or sodium hypochlorite, and chlorine dioxide. Alkalies such as caustic soda and calcium hydroxide are used for extracting chlorinated reaction products from treated pulp. In some instances, hydrogen peroxide or sodium peroxide or peroxyacetic acid are used in the finishing stages of bleaching. Sulfur dioxide or sodium sulfite can be used as neutralizing and antichlor reagents and in some instances to stabilize pulp brightness. However, the chlorine compounds and alkalies are the most commonly applied chemicals. Table 10 presents these and other chemicals used during chemical bleaching. Many of these chemicals are also used to bleach pulp in the other chemical pulping processes.

Table 10 PROCESS CHEMICALS USED FOR CHEMICAL BLEACHING

Chemical	Use	kg/kkg of Product
Chlorine	Bleaching; germicide	75
Calcium Hydroxide	Alkali extraction following bleaching stage; preparation of calcium hypochlorite	
Sodium Hydroxide	Alkali extraction (most widely used); pH control	40
Calcium Hypochlorite	Bleaching (original agent used); oxidizer and germicide	
Sodium Hypochlorite	Alternative hypochlorite	
Sulfamic Acid	pH control	
Chlorine Dioxide	Alternative to hypochlorite bleaching (newer and more widely used)	12.5
Sodium Chlorite	Alternative to chlorine dioxide bleaching; germicide	
Hydrogen Peroxide	Bleaching; wastepaper bleaching and deinking	1-3
Sodium Peroxide	Alternative peroxide	
Peroxyacetic Acid	Alternative to peroxide bleaching	
Sodium Silicate	Stabilizer for peroxide bleaching	15
Magnesium Sulfate	Decomposition inhibitor in peroxide bleaching	0.25
Oxygen	Oxygen bleaching	24-30
Sodium Chlorate	Chlorine dioxide preparation (processes: Mathieson, Holst, Rapson R2 and R3, Solvay, Kesting-Day, Persson-Columbia Southern)	
Sulfur Dioxide	Chlorine dioxide preparation (processes: Mathieson, Holst)	
Sodium Chloride	Chlorine dioxide preparation (processes: Rapson R2 and R3, Kesting-Day)	
Sulfuric Acid	Chlorine dioxide preparation (process: Rapson R3)	
Methanol	Chlorine dioxide preparation (process: Solvay)	
Hydrochloric Acid	Chlorine dioxide preparation (process: Kesting-Day)	
Sodium Hydroxide	Chlorine dioxide preparation (process: Kesting-Day)	
Chromic Sulfate	Chlorine dioxide preparation (process: Persson-Columbia Southern)	

The chemical concentrations employed depend upon the consistency, temperature, number of stages, specific chemicals used, species of wood from which the pulp is produced, and degree to which it is cooked, as well as the quality of product desired. Three stages are generally used in semibleached kraft operations and for bleaching of sulfite paper grade pulps. Since kraft pulps are dark in color, particularly when made from softwoods, high-bright draft pulps usually require more stages. Normally, five stages are used although some mills employ six or more. Three stages may be used for low-brightness soda pulp and four stages for high brightness.

For kraft dissolving grades, the unbleached pulp is purified in the bleach plant to remove all traces of lignin and hemicellulose. This is done by means of a five- to eight-stage process, typically consisting of chlorination, caustic extraction, hypochlorite bleaching, chlorine dioxide bleaching, further caustic extraction followed by more chlorine, chlorine dioxide and hypochlorite. Lignin is removed by chlorine and chlorine dioxide and hemicellulose by caustic extraction. The extremely hot alkaline extraction conditions designed for sulfite dissolving are not useful for the kraft dissolving process in which the alpha cellulose level is determined largely by cooking procedures (15).

The major sources of wastewater from kraft pulping operations are pulp washing, digester and evaporator condensates, chemical recovery and bleaching in bleached kraft mills. Pollution components of kraft pulping include suspended solids, dissolved organics compounds, electrolytes, and inorganic compounds attached to organic compounds. Biologically degradable organic compounds include fatty acids, methanol, ethanol, terpenes, acetone, and other cellulose decomposition products which account for a major percentage of the BOD_5 in kraft mill effluent. The nondegradable organic component (lignins and tannins) is responsible for a large part of the color. Color is especially troublesome in bleached kraft operations because bleaching extracts these color bodies. Chlorides are also a major pollutant contributed by bleaching.

Table 11 presents available data on waste water discharge and raw waste loadings at the five representative mill subcategories of this study area. One of the most significant factors influencing the range of raw waste loadings at kraft mills is the ratio of hardwood to softwood pulp in the furnish. In previous studies, regression analyses of the relationship of raw waste loadings versus percent softwood has been inconclusive, however, and no definite relationship has been established (2). Other factors influencing the variation of BOD, TSS and water usage are the variations in manufacturing processes and types of in plant process controls at different mills.

In Table 12, sampling and analysis results for priority and nonconventional pollutants in "end of the pipe" kraft effluent streams are presented. In this table, concentrations are presented in g/l for raw and treated effluents. All mills sampled used biological treatment systems to reduce the concentrations of these chemicals. In Appendix C, an indepth discussion of specific biological treatment systems is presented.

Table 11 EFFLUENT CHARACTERISTICS OF KRAFT PULP PROCESSING

Subcatgeory		pH	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Unbleached Linerboard	(Range)		6.7-46	4.8-28	23-105
	(Mean)		15	16	47
Bags	(Range)		13-37	8.6-73	33-228
	(Mean)		26	31	116
Bleached Dissolving	(Range)		33-110	29-139	131-306
	(Mean)		65	94	198
Bleached Market	(Range)		18-47	16-132	73-332
	(Mean)		35	29	143
Bleached BCT	(Range)		29-64	15-128	92-192
	(Mean)		47	46	151
Bleached Fine Papers	(Range)	8.9-9.4	6.7-110	4.8-139	23-332
	(Mean)	9	38	43	131
All Kraft Types	(Range)		20-21	4.3	80-125
	(Mean)		--	--	--

In Table 13 the results of a long term sampling study of a bleached kraft mill is presented. Sampling at this mill consisted of long term composite samples of the aeration influent and final effluent. For this mill the aeration influent was the first point at which all wastewater streams were combined.

Many of the substances found during kraft effluent sampling and presented in Tables 12 and 13 are known to be present in bleachery effluents. Many simple dissolved organics present in combined bleachery effluent streams are of low molecular weight and primarily include methanol, methy-ethyl ketone, and formic acid, although small quantities of oxalic, malonic, furmaric, and succinic acids, and acetaldehyde are also present, as well as some chlorinated compounds. In Table 14, substances known to occur in the chlorination tower and extraction tower waste streams are presented along with any known data regarding their kg/kkg of product concentrations (11).

Kraft mill odor problems arise from the use of sodium sulfide as a component of the cooking liquor. In digesters, the sulfide ion combines with various organic side-chain radicals from the cellulose and the ligin of wood chips to form such organic sulfides as methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and small amounts of similar ethyl sulfide compounds. In addition, hydrogen sulfide is formed in considerable amounts. These gases are released with the digester relief and blow gases, as well as from the recovery furnace, lime kiln, smelt dissolving tank, multiple-effect evaporators, black liquor oxidation, brown stock washer, and during condensate stripping (13). Particulate emissions occur primarily from the recovery furnace, the lime kiln, and the smelt dissolving tank. Recovery furnace emissions consist primarily of sodium sulfate and sodium carbonate. Lime

Table 12 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN KRAFT MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	(Subcategory)	Concentration (µg/l)				Percent Reduction
		Untreated	(Raw)	Treated	(Final)	
		Range	Average	Range	Average	
Benzene	(M)	0-3	1	2-3	2	0
	(B)	0	0	0-2	1	0
	(UB)	0-1	1	0-3	1	0
1,1,1-Trichloroethane	(F)	0-71	24	0	0	100
2,4,6-Trichlorophenol	(M)	1-26	11	3-6	5	54.5
	(B)	0-21	8	0-2	1	87.5
	(F)	3-23	11	0-8	3	72.7
Chloroform	(D)	360-900	647	40-86	67	89.6
	(M)	830-2200	1405	6-20	12	99.1
	(B)	580-4000	1550	0-11	6	99.6
	(F)	43-1800	1148	2-110	52	95.5
	(UL)	1-2	1	0	0	100
2,4-Dichlorophenol	(M)	0-8	4	0-8	4	0
	(B)	0-4	2	0-1	1	50
	(F)	0-6	3	0-5	2	33.3
Ethylbenzene	(M)	0-82	27	0	0	100
	(B)	0	0	0-3	1	0
	(UB)	1-2	2	0	0	100
Fluoranthene	(D)	0-7	2	0	0	100
Methylene Chloride	(D)	0-1	1	0	0	100
	(M)	1-2	1	0-2	1	0
	(B)	0-4	2	0-4	2	0
	(F)	2-3	3	0-1	1	66.6
	(UB)	0-290	50	0-6	4	92
	(UL)	2-3	2	0	0	100
Dichlorobromomethane	(D)	0-4	1	0	0	100
	(F)	13-18	15	0	0	100
Isophorene	(UL)	8-15	11	0	0	100
Pentachlorophenol	(B)	5-31	19	16-21	19	0
	(F)	6-11	8	0-1	1	87.5
Phenol	(D)	8-110	54	10-29	18	66.6
	(M)	13-26	20	0-2	1	95
	(B)	25-92	55	0-17	5	90.9
	(F)	4-14	11	0-2	1	90.9
	(UB)	50-140	89	0	0	100
	(UL)	41-110	77	3-4	3	96.1
Bis(2-Ethylhexyl) Phthalate	(D)	15-180	72	0-4	1	98.6
	(M)	6-21	14	7-94	32	0
	(B)	0-35	8	0-11	3	62.5
	(F)	0-190	29	0-49	16	44.8
	(UB)	3-130	49	0-9	3	75
	(UL)	0-7	4	0-4	1	93.9
Butyl Benzyl Phthalate	(UB)	0-39	--	0	0	100
Di-n-Butyl Phthalate	(D)	0-13	7	0-3	1	85.7
	(M)	3-4	4	0-19	8	0
	(B)	0-27	9	0-23	4	55.6
	(F)	0-2	1	0-2	1	0
	(UB)	0-1	1	0	0	100
	(UL)	1-10	7	1-2	1	85.7

Table 12 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN KRAFT MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	(Subcategory)	Concentration (µg/l)				Percent Reduction
		Untreated Range	(Raw) Average	Treated Range	(Final) Average	
Diethyl Phthalate	(D)	0-7	2	0	0	100
	(M)	0-2	1	0	0	100
Anthracene	(D)	0-5	2	0	0	100
	(B)	0-3	1	0	0	100
Pyrene	(D)	0-6	2	0	0	100
Tetrachloroethylene	(B)	1-5	3	0	0	100
	(F)	0-3	1	0	0	100
	(UB)	0-2	1	0	0	100
Toluene	(D)	0-1	1	0	0	100
	(M)	0-5	3	0	0	100
	(B)	0-4	1	0	0	100
	(F)	0-180	23	0	0	100
	(UB)	1-3	2	0	0	100
	(UL)	0-23	6	0	0	100
Trichloroethylene	(B)	1-2	2	0	0	100
Chromium	(D)	5-21	11	<2-19	10	9.1
	(M)	7-20	13	9-73	26	0
	(B)	4-300	85	5-240	55	35.3
	(F)	<2-76	26	2-17	7	73.1
	(UB)	12-26	18	5-17	12	33.3
	(UL)	<2-11	7	5-8	7	0
Copper	(D)	39-42	40	<2-42	17	57.5
	(M)	24-37	31	4-26	14	54.8
	(B)	18-70	46	<2-42	17	63.0
	(F)	9-48	22	<1-23	8	63.6
	(UB)	12-46	24	4-15	9	62.5
	(UL)	<2-16	9	<2-17	5	44.4
Lead	(D)	5-7	6	<2-15	8	0
	(M)	<1-18	9	<1-29	9	0
	(B)	<1-54	17	3-45	18	0
	(F)	<2-10	6	<1-15	6	0
	(UB)	5-24	14	2-34	16	0
	(UL)	2-20	<13	2-10	5	61.5
Mercury	(D)	<0.5	<0.5	<0.5	<0.5	--
	(M)	<0.5	<0.5	<0.5	<0.5	--
	(B)	<0.5	<0.5	<0.5	<0.5	--
	(F)	<0.5	<0.5	0.5-0.9	<0.5	--
	(UB)	<0.5	<0.5	0.5	<0.5	--
	(UL)	<0.5	<0.5	0.5	<0.5	--
Nickel	(D)	<2-8	5	2-15	10	0
	(M)	16-59	31	8-18	14	54.8
	(B)	<2-120	36	<2-30	12	66.7
	(F)	<2-33	16	1-16	8	50
	(UB)	<2-12	6	<2-10	5	16.7
	(UL)	<2-9	5	3-6	5	0

Table 12 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN KRAFT MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	(Subcategory)	Concentration (µg/l)				Percent Reduction
		Untreated	(Raw)	Treated	(Final)	
		Range	Average	Range	Average	
Zinc	(D)	73-78	75	44-51	48	36
	(M)	100-185	154	46-91	61	60.4
	(B)	74-200	138	45-360	100	20.3
	(F)	67-290	149	36-208	72	51.7
	(UB)	41-230	136	16-150	81	40.4
	(UL)	37-120	71	27-100	67	5.6
Abietic Acid	(D)	8600-18000	11800	100-2500	1467	87.6
	(M)	6-390	178	0-1800	767	0
	(B)	0-2700	1043	0-520	119	88.6
	(F)	190-1100	470	0-11	3	99.4
	(UB)	3700-12000	6983	30-250	165	97.6
	(UL)	350-1200	753	0-21	10	98.7
Dehydroabietic Acid	(D)	3000-5200	3500	0-800	520	98.5
	(M)	10-560	232	2-1000	431	85.8
	(B)	280-1400	861	48-310	123	85.7
	(F)	140-430	273	3-7	5	98.2
	(UB)	950-27600	7142	30-200	85	98.8
	(UL)	330-640	470	6-15	11	97.6
Isopimaric Acid	(D)	660-1300	887	160-590	380	57.2
	(M)	66-180	115	230-500	407	0
	(B)	0-250	107	0-86	21	80.4
	(F)	54-110	74	0-3	1	98.6
	(UB)	380-1600	770	0-32	15	98.1
	(UL)	78-450	283	0-10	6	97.9
Pimaric Acid	(D)	970-1900	1357	620-790	710	47.7
	(M)	120-200	157	320-530	430	0
	(B)	0-350	115	0-74	22	80.9
	(F)	20-93	63	0	0	100
	(UB)	420-2500	1168	10-60	32	97.3
	(UL)	38-51	43	0-3	1	97.7
Oleic Acid	(D)	3000-4500	3667	0-810	333	90.9
	(M)	250-520	345	22-250	153	55.7
	(B)	0-2900	1084	0-92	17	98.4
	(F)	16-970	276	15-130	41	85.1
	(UB)	1700-6700	3133	0-150	70	97.8
	(UL)	160-500	337	4-65	38	88.7
Linoleic Acid	(D)	2200-3900	2900	0-510	170	41.4
	(M)	220-2300	792	26-100	64	91.9
	(B)	180-1300	762	0	0	100
	(F)	170-470	283	2-7	4	98.6
	(UB)	610-1700	958	0	0	100
	(UL)	150-270	203	0	0	100
Linolenic Acid	(M)	22-210	126	40-53	47	62.7
	(F)	42-93	71	0	0	100
	(UB)	67-3170	1543	0	0	100
Epoxystearic Acid	(D)	800-850	817	0	0	100
Chlorodehydroabietic Acid	(D)	1300-1600	1433	300-700	473	67
	(M)	0-120	50	0-140	42	16
	(B)	0-190	78	0-31	11	85.9
	(F)	2-240	44	0	0	100

Table 12 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN KRAFT MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction
		Untreated	(Raw)	Treated	(Final)	
		Range	Average	Range	Average	
Dichlorodehydroabietic Acid	(M)	30-86	57	11-65	39	31.6
	(B)	0-15	3	0-4	1	66.7
	(F)	0-32	6	0	0	100
Trichloroguaiacol	(M)	15-21	18	0	0	100
	(B)	0-1	1	0	0	100
	(F)	0-9	4	0-2	1	75
Tetrachloroguaiacol	(M)	4-23	11	0	0	100
	(B)	2-17	8	0-1	1	87.5
	(F)	4-17	7	0-8	3	57.1
Xylenes	(F)	0-8	--	0	0	100
	(UB)	22-44	--	0	0	100
	(UL)	8-10	--	0	0	100
Color	(D)	1086-2220^a	1475	935-1326^a	1160	21.4
	(M)	1420-1920^a	1680	1310-1920^a	1597	4.9
	(B)	875-2030^a	1233	1340-2040^a	1610	0
	(F)	630-1210^a	850	430-1380^a	826	2.8
	(UB)	340-1900^a	1130	350-2400^a	1208	0
	(UL)	70-290^a	173	190-240^a	213	0
COD	(D)	1290-1510^b	1400	330-780^b	497	64.5
	(M)	530-920^b	735	370-440^b	407	44.6
	(B)	300-1270^b	765	290-470^b	397	48.1
	(F)	400-820^b	576	110-310^b	244	57.6
	(UB)	590-1840^b	1113	345-1000^b	663	40.4
	(UL)	550-670^b	617	220-490^b	310	49.8

Subcategory Key:
B - BCT
D - Dissolving
F - Fine
M - Market
UB - Unbleached Bags
UL - Unbleached Linerboard

[a] Color concentrations given in platinum cobalt units
[b] COD concentrations given in mg/l

Kiln

kiln emissions are primarily sodium salts, calcium carbonate, and calcium oxide. Smelt dissolving emissions are caused primarily by the entrainment of particles and odorous materials in the vent gases. Particulate emissions are also generated by power and bark boilers.

A summary of the known data on the occurrences and variations in the rates of gaseous emissions from various process components of kraft pulping is presented in Table 15. Extreme variations in operating conditions that occur at different kraft mills, including operating combustion temperatures and fuel types, account for the broad ranges for much of this quantified information.

Table 13A LONG-TERM SAMPLING FOR NONCONVENTIONAL POLLUTANTS AT A FINE BLEACHED KRAFT MILL (1)

Chemical	Concentration Range (μg/l)		Average Concentration (μg/l)	
	Secondary Influent	Final Effluent	Secondary Influent	Final Effluent
Abietic Acid	200-12000	0-8000	1890	298
Dehydroabietic Acid	12-1800	0-1300	259	37
Isopimaric Acid	140-4900	0-3900	775	154
Pimaric Acid	0-530	0-370	70	11
Oleic Acid	0-6700	0-3700	1130	119
Linoleic Acid	390-12000	0-3900	2160	108
Linolenic Acid	0-480	0-25	50	0.6
Epoxystearic Acid	85-490	0-63	208	9.7
Dichlorostearic Acid	0-640	0-125	175	19
Monochlorodehydroabietic Acid	0-217	0-110	66	8.1
Dichlorodehydroabietic Acid	0-41	0-33	9.6	2.6
3,4,5-Trichloroguaiacol	0-4	0-7	0.6	0.7
Tetrachloroguaiacol	0-2	0-6	0.2	0.3
Palustric Acid	0-1800	0-1100	170	25
Levopimaric Acid	0	0-66	0	1.5
4,5,6-Trichloroguaicol	0	0-2	0	0
Neoabietic Acid	0-5200	0-3000	818	95
4,5-Dichloroguaiacol	0-1	0	0	0
Sandaracopimaric Acid	0-690	0-570	125	17
2,4,5-Trichlorophenol	0	0	0	0
Dimethyl Sulfide	480-3740	0-230	1370	55
Dimethyl Disulfide	38-1800	0-13	743	0.6

Table 13B LONG-TERM SAMPLING FOR TOXIC POLLUTANTS AT A FINE BLEACHED KRAFT KRAFT MILL (1)

Chemical	Concentration Range (μg/l)		Average Concentration (μg/l)	
	Secondary Influent	Final Effluent	Secondary Influent	Final Effluent
2,4,6-Trichlorophenol	0-5	0-6	1.8	2.7
Chloroform	227-772	21-230	404	58
2,4-Dichlorophenol	0-1	0-2	0.1	0.1
Pentachlorophenol	0-11	0-7	1.2	0.8

Table 14 SUBSTANCES FOUND IN SPENT LIQUOR FROM CHLORINATION AND ALKALINE EXTRACTION (6)

Compound	Concentration	
	Chlorination Tower kg/kkg	Extraction Tower kg/kkg
Dichlorophenol	--	--
2,4,6-Trichlorophenol	0.9	1.8
2,6-Dibromophenol	--	--
Dichloroguaiacol	--	--
Trichloroguaiacol	--	2.5-2.7
Dichlorocatechol	--	--
Trichlorocatechol	0.6-3.0	--
Tetrachloroguaiacol	--	2.2
Monochloropropiovanillone	--	--
Tetrachlorocatechol	1.6	0.9

Many substances generated during kraft pulping operations are considered useful by-products. In Table 16 a list of these materials is presented along with their associated process components of origin.

Solid wastes generated from kraft mill recovery systems include rejects from slakers, where lime is reacted with water to form calcium hydroxide, and unburned lime rejects from the lime kilns. Dewatered dregs are generated from the green liquor clarifier and discharged as inert solid wastes, such as iron compounds, carbon, grit, and refractory materials; dewatered dregs account to about 22.5 kg/kkg of pulp produced (13).

SODA PULP PROCESSING (STUDY AREA 3)

Alkaline pulping originally used sodium hydroxide as the active pulping chemical. Small amounts of sulfur compounds found their way into the cooking chemical system so that the original soda mills had a sulfidity of around 5% or less. It was found that the presence of the sulfide in the cooking liquor improved the yield and strength of the pulp, where particles or knotts are removed from unwashed pulp. The kraft industry developed when sodium sulfate was used as the make-up chemical in place of soda.

The equipment and operation used in soda pulping are essentially the same as that used in the typical kraft type process without use of sulfur compounds. Figure 5 (kraft process flow) can, therefore, be referred to for a description of the soda process. Process control measures applicable to the soda process are presented in Table 17, and are also illustrated in Figure 5. An in-depth discussion of these process controls is presented in Appendix B.

Chips at 45% moisture are pulped to a 47% yield using 18% chemical on wood and at a liquor to wood ratio of 3:1 in a continuous digester. The

Table 15 GASEOUS EMISSIONS IN KRAFT MILLS

Process Component	Waste Description	kg/kkg of Product
Digester (Batch)		
Blow:	Hydrogen Sulfide	0-0.1
	Methanethiol (Methyl Mercaptan)	0-1.0
	Dimethyl Sulfide	0-2.5
	Dimethyl Disulfide	0-1.0
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
Relief:	Hydrogen Sulfide	0-0.05
	Methanethiol	0-0.3
	Dimethyl Sulfide	0.05-0.8
	Dimethyl Disulfide	0.05-1.0
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
Digester (Continuous)	Hydrogen Sulfide	0-0.1
	Methanethiol (Methyl Mercaptan)	0.5-1.0
	Dimethyl Sulfide	0.05-0.5
	Dimethyl Disulfide	0.05-0.4
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
Blow Tank	Hydrogen Sulfide	
	Methyl Mercaptan	
	Dimethyl Sulfide	
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	

Table 15 (Continued) GASEOUS EMISSIONS IN KRAFT MILLS

Process Component	Waste Description	kg/kkg of Product
Brown Stock Washer(s) (Hood Vent)	Hydrogen Sulfide	0-0.1
	Methanethiol	0.5-1.0
	Dimethyl Sulfide	0.05-0.5
	Dimethyl Disulfide	0.05-0.4
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
(Seal Tank)	Hydrogen Sulfide	0-0.01
	Methanethiol	0-0.01
	Dimethyl Sulfide	0-0.05
	Dimethyl Disulfide	0-0.03
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
Tall Oil Recovery Evaporator (Hotwell)	TRS (Total Reduced Sulfur)	0.01-0.66 Mean = 0.15
	Steam	500-1000
	Hydrogen Sulfide	0.05-1.5
	Methanethiol	0.05-0.8
	Dimethyl Sulfide	0.05-1.0
	Dimethyl Disulfide	0.05-1.0
Black Liquor Oxidation Tower	Hydrogen Sulfide	0-0.01
	Methanethiol	0-0.1
	Dimethyl Sulfide	0-0.4
	Dimethyl Disulfide	0-0.3
Direct Contact Evaporator	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
Recovery Furnace (After Direct Contact Evaporator)	Steam	
	Flue gas	
	- Nitrogen Oxides	0-5.0
	- Hydrogen Sulfide	0-25.0
	Methanethiol	0-2.0
	Dimethyl Sulfide	0-1.0

Table 15 (Continued) GASEOUS EMISSIONS IN KRAFT MILLS

Process Component	Waste Description	kg/kkg of Product
Recovery Furnace (After Direct Contact Evaporator) (Continued)	Dimethyl Disulfide	0-1.3
	Sulfur Dioxide	0-50.0
	Sulfur Trioxide	0-6.0
	Other Gases	
	- Carbon Dioxide	1.2
	- Oxygen Nitrogen	4.5
	Smelt	
	- Sodium Sulfide	
	- Sodium Carbonate	
	- Sodium Triosulfate	
	- Sodium Sulfate	
	- Polysulfides	
	Dust (Entrained in Gas)	
	- Sodium Sulfate	Total = 0.5- 12
	- Sodium Carbonate	
	- Sodium Chloride	
Smelt Dissolving Tank	Steam	150-250 kg
	Hydrogen Sulfide	0-1.0
	Methanethiol (Methyl Mercaptan)	0-0.8
	Dimethyl Sulfide	0-0.5
	Dimethyl Disulfide	0-0.3
	Particulate (After Control)	0.01-0.5
	Organic Wood Compounds	
	- Terpenes	
	- Hydrocarbons	
	- Alcohols	
	- Phenols	
	Sulfur Dioxide	0-0.2
Lime Kiln Exhaust	Steam	350-750
	Nitrogen Oxides	10-25
	Hydrogen Sulfide	0-0.5
	Methanethiol (Methyl Mercaptan)	0-0.2
	Dimethyl Sulfide	0-0.1
	Dimethyl Disulfide	0-0.05
	Sulfur Dioxide	0-1.4
Lime Kiln and Fluidized Bed Reactors	Hydrogen Sulfide	0-1.88
	Methanethiol	0-0.17
	Dimethyl Sulfide	0-0.22

Table 15 (Continued) GASEOUS EMISSIONS IN KRAFT MILLS

Process Component	Waste Description	kg/kkg of Product
Lime Kiln and Fluidized Bed Reactors (Continued)	Dimethyl Disulfide	0-0.10
	Sulfur Dioxide	0-1.11
	Particulate	0.15-2.5
Lime Slaker	Hydrogen Sulfide	0-0.01
	Methanethiol (Methyl Mercaptan)	0-0.01
	Dimethyl Sulfide	0-0.01
	Dimethyl Disulfide	0-0.01
Direct Contact Evaporator (Unoxidized Black Liquor)	Hydrogen Sulfide	2.5-15.0
	Methanethiol	0.15-1.0
	Dimethyl Sulfide	0.02-0.075
	Dimethyl Disulfide	0.05-0.15
(Oxidized Black Liquor)	Hydrogen Sulfide	0.05-1.0
	Methanethiol	0.025-0.10
	Dimethyl Sulfide	0.005-0.025
	Dimethyl Disulfide	0.005-0.075
Power Boilers		
Oil:	Sulfur Dioxide	1.7
	Nitrogen Oxides	.47
	Hydrocarbons	.001
	Carbon Monoxide	.001
	Particulates (unburned or partially burned fuel)	
	Trace Elements	
	- Nonmetals	
	. Fluorine	
	. Chlorine	
	. Phosphorous	
	- Heavy Metals	
	. Beryllium	
	. Mercury	
	. Lead	
	. Cadmium	
	. Zinc	
	. Arsenic	
	. Selenium	
Coal:	Sulfur Dioxide	2.6
	Nitrogen Oxides	.8
	Hydrocarbons	.013
	Carbon Monoxide	.043

Table 15 (Continued) GASEOUS EMISSIONS IN KRAFT MILLS

Process Component	Waste Description	kg/kkg of Product
Coal: (Continued)	Particulate (Unburned or partially burned fuel)	.4
	Fly Ash (quartz, aluminum oxides, alkali oxides)	
	Trace Elements	
	- Nonmetals	
	. Fluorine	
	. Chlorine	
	. Phosphorous	
	- Heavy Metals	
	. Beryllium	
	. Mercury	
	. Lead	
	. Cadmium	
	. Zinc	
	. Arsenic	
	. Selenium	
Natural Gas:	Sulfur Oxides	.001
	Nitrogen Oxides	.33
	Hydrocarbons	.033
	Carbon Monoxide	.001
	Particulate (Unburned or partially burned fuel)	.012
Waste Wood:	Sulfur Oxides	0.3
	Nitrogen Oxides	.89
	Hydrocarbons	.23
	Carbon Monoxide	.23
	Particulate	.52
Chlorine Dioxide Tower	Carbon Monoxide	
Sulfur Dioxide Absorption Tower (final bleached pulp treatment)	Sulfur Dioxide	1.5
Sheet Forming Dyring Machine	Chlorine Dioxide	
Chlorine Dioxide Towers	Chlorine Dioxide	0.3
Chlorination Tower	Dichlorine Monoxide	
Chlorination Tower Vent and Succeeding Wash	Chlorine	0.5

Table 16 BY-PRODUCTS RECOVERED DURING KRAFT PULPING

Process Component	Waste Description	kg/kkg of Product
Digester Condensate	Turpentine	
Black Liquor Oxidation Tank (Skimmings)	Tall Oil Soap	30
Black Liquor Recovery	Sodium Sulfate Sodium Carbonate Sodium Sulfide	
Green Liquor Recovery	Calcium Carbonate	
Green Liquor Causticizing	Calcium Oxide Sodium Hydroxide	

Table 17 SODA PROCESS CONTROL MEASURES

Process Component Area	Control Measure Description
Pulpwood Preparation	1 Close-up or dry woodyard and barking operation
	2 Segregate cooling water
Digester	3 Reuse blow condensates
Digester, Liquor Storage, Brown Stock Washers	5 Spill collection
Pulp Washing Lines	6 Installation of 4th stage washer
Bleach Plant	9 Countercurrent or jumpstage washing
Evaporator/Recovery Area	13 Install boil out tank
Liquor Storage, Causticizing	16 Area Spill collection
Lime Kiln Area	19 Spill collection
Papermaking	20 Paper machines/bleached pulp spill collection
	Color plant spill collection
	23 White water use for vacuum pump sealing
	27 Reuse of vacuum pump water
	29 Installation of wet lap machine
Steam Plant/Utility Areas	33 Segregate cooling water
	34 Lagoon for boiler blowdown and backwash waters

cooking chemical is sodium hydroxide. The pulp is washed countercurrently using water from the knotter, where particles or knotts are removed from unwashed pulps. The pulp is then bleached in a three-stage sequence to obtain low-brightness pulp and in a four-stage sequence for high brightness pulp. Bleaching losses are assumed to be 8%. The black liquor is evaporated and burned in a recovery furnace. The resulting green liquor is causticized (9).

Potassium hydroxide has been studied as a base in place of sodium hydroxide. Potassium hydroxide is a more selective pulping agent than sodium hydroxide and, therefore, produces greater yields (9). If potassium hydroxide is to be used in a mill, washing efficiency of the pulp must be greatly increased to reduce losses of cooking chemicals, since potassium hydroxide is considerably more expensive than sodium hydroxide or sodium sulfate.

Approximately 83.5 to 170 kl/kkg of effluent are generated in soda pulping, the specific volume depending largely on cooling requirements. Reuse of paper machine water in the pulp mill is limited by the filters used in the manufacture of printing papers from soda pulp which render this water unsuitable unless it is clarified to a high degree (3).

The major effluent sources from a soda pulp mill are decker (pulp thickener) seal pit water, digestor relief condensates, evaporator condensates, bleach plant effluent, spills, and miscellaneous wastewaters, including recovery plant discharge, boiler plant blowdown and effluent treatment wastes.

Soda pulping effluents contain resin acid soaps and turpene derivatives. Since sulfur is not used in the process, the effluent is slightly less toxic than is kraft. In Table 18, a summary of known data on the range of raw wastes in soda mill effluents are presented. Half of the BOD originates from bleaching operations. After primary and biological effluent treatment, BOD and TSS are reduced to the order of 7 kg/kkg and 13 kg/kkg respectively (4). Using the mean values presented for BOD and TSS in Table 18, the effectiveness of effluent treatment is computed as:

BOD 25 kg/kkg 7 kg/kkg = 72% reduction
TSS 25 kg/kkg 13 kg/kkg = 48% reduction

An indepth discussion of the various primary and biological treatment options applied to this and other pulp and paper mill operations is presented in Appendix C.

Table 18 EFFLUENT CHARACTERISTICS OF SODA PULP PROCESSING

	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Range	20-53	20-145	84-170
Mean	25	25	104

The lack of sulfur as a pulping chemical allows emissions from a soda pulping mill with greatly reduced odor compared with kraft. Some reduced sulfur odors do occur because of an unintentional buildup of sulfur in the cooking chemical cycle. Sulfur compounds are converted to their reduced state in the recovery furnace. In Table 19, the occurrence of reduced sulfur and other gaseous emissions of significance are presented for a soda mill.

Table 19 GASEOUS EMISSIONS IN SODA MILLS

Process Component	Waste Description	kg/kkg of Product
Recovery Furnace	Reduced Sulfur	2×10^{-4}-0.01[a]
	Nitrogen Oxides	3.2
	Particulates	1.55
Smelt Tank	Particulates	0.25
Lime Kiln	Sulfur Dioxide	T[b]-0.32
	Nitrogen Oxides	23.6
	Particulates	0.5
Power Boilers		
Coal:	Sulfur Dioxide	0.8
	Nitrogen Oxides	0.25
	Particulates	0.12
Oil:	Sulfur Dioxide	0.5
	Nitrogen Oxides	0.14
Wood:	Sulfur Dioxide	0.1
	Nitrogen Oxides	0.27
	Particulates	0.16
Total Mill	Sulfur Dioxide	0.94
	Nitrogen Oxides	21.1
	Particulates	2.8

[a] Varies according to the effectiveness of control euipment.
[b] Trace amounts.

Solid wastes from a soda mill occur from 4 main sources: 1) process losses including wood preparation, green liquor dregs, washing and screening losses, bleach plant wastes, drying wastes and spills; 2) water treatment sludges; 3) fly ash; and 4) biological solids developed from treatment of effluents.

Process losses can be estimated by assuming they are 90% of the raw waste load suspended solids, or that which would be removed in the primary clarifier. Process loss solid wastes are estimated to be 22 kg/kkg (5). Water treatment waste solids depend upon the quantity and quality of water treated. The variables are too numerous to attempt an estimate of solids produced. Fly ash generation depends the quantity of energy required and the type of fuel used in the boiler. Bark and coal produce the greatest quantity of fly ash, whereas gas or oil produce none.

Solids derived from the biological treatment of effluents are the largest solid waste disposal problem. They have a high volume to dry weight ratio when wet and are difficult to dewater. The quantity of biological solids produced depends upon the quantity and quality of the effluent and the detention time of the secondary treatment. Activated sludge systems produce more solids than an aerated lagoon. Overall, a soda mill produces about the same quantity of solids as a kraft mill.

SULFITE PULP PROCESSING (STUDY AREA 4)

The sulfite process is used to make two distinctly different types of pulp-papermaking grades and dissolving grades. The basic process is the same for both, although there are differences in cooking temperatures, strength of chemical application, and bleaching practices. The flow diagram presented in Figure 12 is generally applicable to both process variations. The process controls presented in Table 20 are numbered as they appear in the flow diagram. These controls, which serve to improve the efficiency of the process as well as to reduce waste loadings, are discussed in Appendix B.

In the sulfite process, wood chips are cooked with acidic solutions of the sulfites of calcium, magnesium, ammonia, or sodium. The cooking liquor is manufactured at the mill from purchased and recovered chemicals. These chemicals are presented in Table 21. No data are available to quantify the occurrences of these chemicals relative to unit production of pulp.

Sulfurous acid is prepared by absorbing sulfur dioxide in water. Sulfur dioxide is made at the mill by burning sulfur or is purchased in liquid form, either of which is supplemented by that returned to process from the sulfur dioxide recovery system.

In calcium base mills, calcium is supplied either in the form of calcium carbonate or calcium oxide; the base is reacted with sulfurous acid and is not usually recovered from the spent liquor. In ammonia base mills, aqueous ammonia is reacted with sulfurous acid. If the chemical is purchased in the anhydrous form, it is first put into solution. Ammonia, too, is not recovered. Magnesium oxide and caustic soda are purchased as make-up base for the magnesium and sodium base recovery systems which retain about 90% of the base in the system through recovery (15).

When cooking is completed, the pulp is blown into a blow tank. It is then delivered to multi-stage vacuum washers on which countercurrent washing separates the spent liquor from the pulp. In some cases, blow pits rather than tanks are employed where the pulp is washed by diffusion of wash water through the pulp mass. It is possible to recover 95% of the liquor solids by vacuum washing, but the limit is about 85% from displacement washing in blow pits. A 15% liquor concentration is obtainable by vacuum washing while the

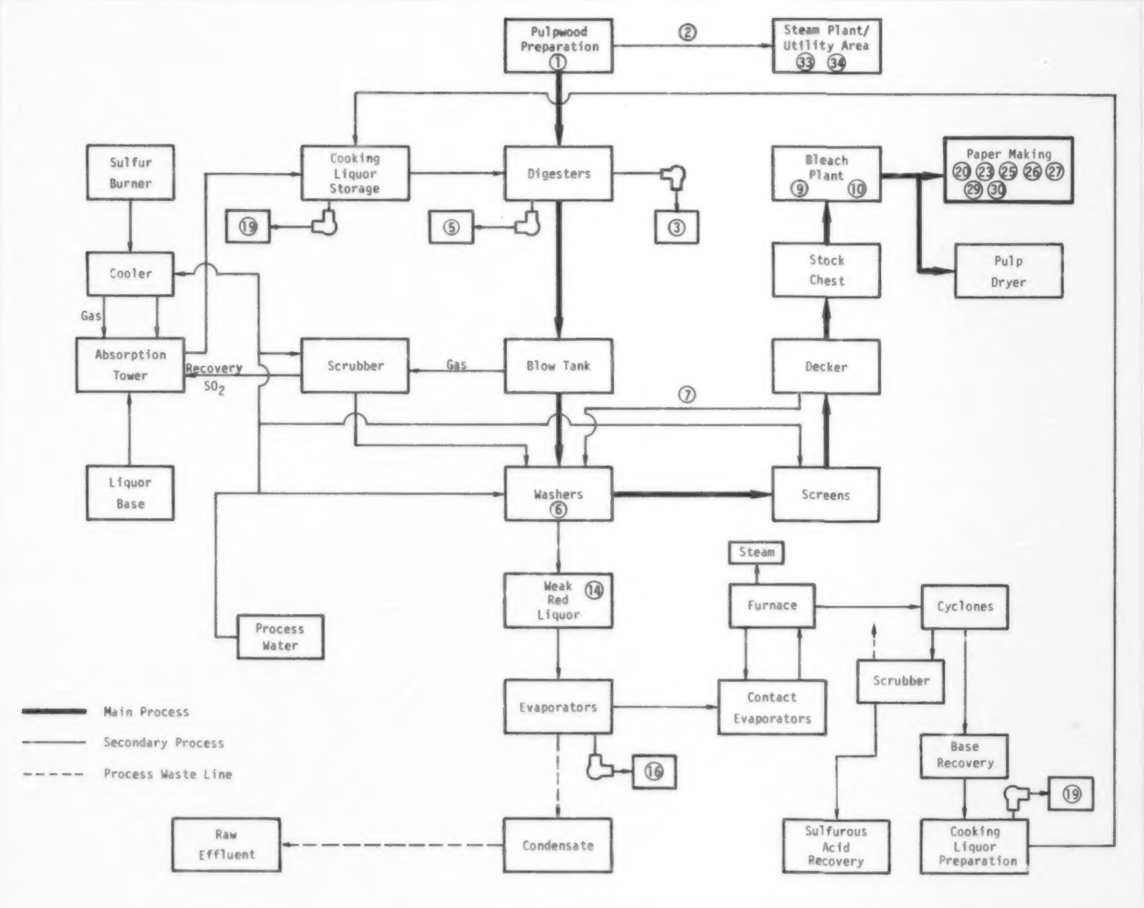


Figure 12 Sulfite Pulp Process Flow Diagram

highest solids concentration attainable by blow-pit washing is about 10%. Off-gases are passed to an absorption system for recovery of their sulfur dioxide content. After washing, the pulp is diluted, screened, centrifugally cleaned, and deckered to the desired stock chest consistency for bleaching. Figure 13 shows a basic decker design.

The weak red liquor separated from the pulp is evaporated to a consistency of 50% to 60% solids which is suitable for burning. Because of scaling problems, special evaporation units of the switching type are required for calcium base liquor. Also, forced fed evaporators must be used for ammonia base liquor because of its high viscosity.

Table 20 SULFITE PROCESS CONTROL MEASURES

Process Component		Control Technology Description	Dissolving	Papergrade
Pulpwood Preparation	1	Close-up or dry woodyard and barking operation	●	●
	2	Segregate cooling water	●	
Digester	3	Reuse blow condensates	●	●
Digester, Liquor Storage, Brown Stock Washers	5	Spill collection	●	●
Washers & Screen Room	6	Add third stage washer	●	●
	7	Recycle decker filtrate	●	
Bleach Plant	9	Countercurrent or jumpstage washing	●	●
	10	Evaporate caustic extraction stage filtrate	●	
Evaporator/Recovery Area	14	Neutralize spent sulfite liquor	●	●
	16	Spill collection		●
Liquor Preparation Area	19	Spill collection	●	●
Papermaking	20	Paper machines/bleached pulp spill collection	●	●
	20	Color plant spill collection		●
	23	White water use for vacuum pump sealing	●	●
	25	White water storage for upsets and pulper dilution	●	
	27	Reuse of vacuum pump water	●	●
	29	Installation of wet lap machine		●
	30	Segregate cooling water		●
Steam Plant/Utility Areas	33	Segregate cooling water	●	●
	34	Lagoon for boiler blowdown and backwash waters		●

In the magnesium base process, the ash produced on burning the liquor is magnesium oxide which is recovered in cyclones and returned to the liquor manufacturing section of the mill. The smelt obtained on burning sodium base liquor is solidified and redissolved under controlled conditions so that the soda ash and sodium sulfide present can be separated by differential solubility. The sodium sulfide is reacted with carbonic acid to form hydrogen sulfide which is burned to produce sulfur dioxide. The latter is reacted with the soda ash obtained from the smelt to form sodium bisulfite cooking liquor, and the carbon dioxide produced is employed in the sodium sulfide reaction. Ammonia base liquor is burned either in a recovery furnace or a fluidized bed unit. Sulfur dioxide is stripped from the off-gases for use in the liquor preparation unit.

In the preparation of sulfite dissolving pulps, the wood is cooked at a higher temperature than for papergrade pulps (15). Cooking is continued until most of the lignin and part of the cellulose are dissolved whereas in papermaking pulps only the lignin is dissolved. The resulting spent liquor thus has a higher solids content when burned. In addition to screening to remove bark and wood particles after the pulp is washed, it is often sent through screens for thickening and to separate resinous materials.

Table 21 SULFITE PULPING PROCESS CHEMICALS

Chemical	Use
Calcium Oxide	Calcium base pulping
Calcium Carbonate	Calcium base pulping
Calcium Hydroxide	Calcium base pulping
Dolomite	Calcium base pulping
Ammonia (aqueous or anhydrous)	Ammonia base pulping
Magnesium Oxide	Magnesium base pulping
Magnesium Hydroxide	Magnesium base pulping
Sodium Hydroxide	Sodium base pulping
Sodium Carbonate	Sodium base pulping
Sulfurous Acid	Pulping mixed with one of the four bases to form sulfite cooking liquor
Sulfur Dioxide	Preparation of sulfurous acid
Sulfur	Burned to obtain sulfur dioxide
Hydrogen Sulfide	Alternate source of sulfur
Carbonic Acid	Used in sodium base recovery: reacted with sodium sulfide in smelt to form hydrogen sulfide
Carbon Dioxide	Also employed during this reaction. Formed during mix of sulfur dioxide and soda ash (sodium carbonate)
Sodium Bisulfite	The product of this mix: the sodium base pulping liquor

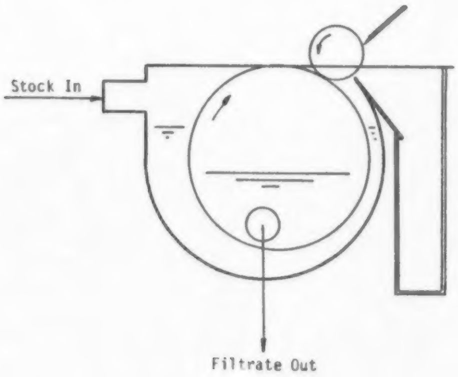


Figure 13 Typical Gravity Decker

The purpose of the caustic extraction stage in bleaching dissolving sulfite pulps is somewhat different from its function in bleaching sulfite papergrade pulps. In the latter, this stage is used to remove partially bleached material solubilized in the chlorination stage. In the manufacture of dissolving pulp, the extraction stage is much more drastic in terms of caustic concentrations and degree of heat in order to dissolve a specific fraction of the cellulose itself which is not suited to the manufacture of rayon. Over 45 kg of caustic may be added per kkg of pulp and reaction temperatures exceed the boiling point while only about 14 kg of caustic under warm conditions are required for papergrade pulp. In dissolving pulp bleaching, this step dissolves from 15 to 20% of the pulp, depending on the grade of cellulose desired.

The three stage bleaching process is usually used to bleach papergrade pulps. In Figure 14, a process flow diagram is presented for such a three-stage process. Dissolving pulps usually undergo one or more additional stages such as chemical purification and ash removal. The complex bleaching and purification sequence in which these steps are employed and the chemicals used are essentially the same as those presented for the description of kraft bleaching in this section.

Raw waste levels in sulfite wastewaters are most significantly affected by wood type, pulp washing and recovery of spent liquor, condenser type, type of cooking liquor and bleaching operations. In Table 22, a summary of available data on the ranges of sulfite pulping effluents are presented for the three subcategories considered for this study area. The dissolving sulfite subcategory uses essentially the same basic process as the paper grade subcategories. However, since both the cooking and bleaching stages are more stringent for the dissolving subcategory, BOD levels are considerably higher in the effluent, as over 60% of the wood may become waste material.

In Table 23, data are presented for individual waste streams eminating from the pulping and bleaching processes of a typical paper grade sulfite mill. Many substances generated during sulfite pulping are considered useful by-products. In Table 24, a list of these materials is presented along with their associated process components of origin.

Pulping effluents typically consist of lignosulfonates, lower fatty acids, alcohols, ketones, wood sugars and a number of other complex compounds such as cymene. The lignin fraction is largely responsible for effluent color, the degree of which depends on the efficiency of the liquor separation and recovery system as well as the type of base (calcium, magnesium, ammonium, sodium) employed and the wood species pulped. Many of these materials are classified as nonconventional and priority pollutants. In Table 25, a summary of the analysis results of "end of the pipe" waste water concentrations of these materials is presented. This table includes the identification and effectiveness of any known effluent treatment measure type. An indepth discussion of the various primary and biological treatment measures which may be applied to sulfite and other mills throughout the industry is presented in Appendix C.

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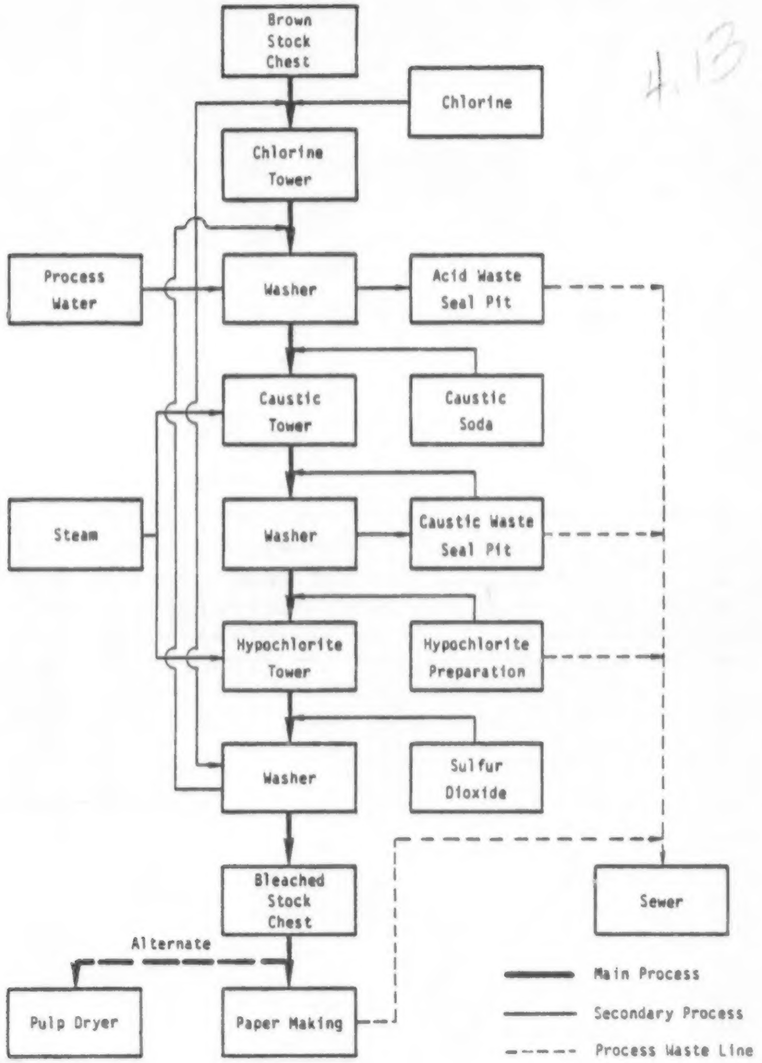


Figure 14 Three-Stage Sulfite Pulp Bleach Plant Process Flow Diagram

Table 22 EFFLUENT CHARACTERISTICS OF SULFITE PULP PROCESSING

Subcategory		pH	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Papergrade Blow Pit Wash	(Range)		28-116	19-51	98-347
	(Mean)		--	--	--
Papergrad Drum Wash	(Range)		36-192	12-140	59-254
	(Mean)		--	--	--
Dissolving Grade	(Range)		97-276	11-54	183-359
	(Mean)		161	31	259
All Mill Types		2.5-3.2	28-276	11-140	59-359

Table 23 EFFLUENT LOADING FROM INDIVIDUAL PROCESS COMPONENTS IN SULFITE PULP MILL

	pH	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Blow Tank	2.2-2.9	58	0.5	7.9
Condensates	2.3-3.1	33	0.05	4.6
Liquor Losses	2.2-2.6	27	11	31
Screening	5.4-5.7	4.0	4.0	25
Washing and Thickening	2.4-3.9	9.0	4.0	31
Acid Plant Wastes	1.2	1	2.5	1.3
Boiler Blow Down	--	1	1.0	0.4

Table 24 BY-PRODUCTS RECOVERED DURING SULFITE PULPING

Process Component	Description
Incineration (Magnesium-Base) Liquor	Magnesium Oxide (Ash) Sulfur Dioxide (Flue Gas)
Incineration (Ammonium-Base) Liquor	Sulfur Dioxide (Flue Gas)
Incineration (Sodium-Base) Liquor	Soda Ash (Ash) Sodium Sulfide (Ash) Sulfur Dioxide (Flue Gas)
Spent Liquor Recovery	Spent Liquor (Fermented to produce yeast and alcohol)
Spent Liquor Recovery	Vanillin
Spent Liquor Recovery	Lignosulfonates

Table 25 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN SULFITE MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	(Subcategory)	Concentration (µg/l) Untreated Range	(Raw) Average	Treated Range	(Final) Average	Percent Reduction
Benzene	(D)	0-2	1	0	0	100
	(P)	0-150	57	0-96	16	71.9
1,1,1-Trichloroethane	(P)	130-2000	1243	6-8	7	99.4
1,1-Dichloroethane	(P)	5-22	12	0	0	100
2,4,6-Trichlorophenol	(D)	7-15	11	1-7	5	54.5
	(P)	10-370	181	2-270	106	41.4
Chloroform	(D)	110-360	268	1-42	13	95.1
	(P)	62-8600	2677	120-1200	433	83.8
2-Chlorophenol	(P)	0-120	65	21-50	37	43.1
2,4-Dichlorophenol	(D)	0-4	2	0-1	1	50
	(P)	2-220	103	0-130	53	48.5
Fluoranthene	(D)	0-4	1	0-1	1	0
Methylene Chloride	(D)	0-3	2	0-2	1	50
	(P)	0-2500	291	2-3100	271	6.9
Dichlorobromomethane	(P)	8-40	26	0-5	2	92.3
Naphthalene	(D)	3-4	4	0	0	100
	(P)	22-230	102	7-88	36	64.7
Pentachlorophenol	(P)	1-12	6	0-1	1	83.3
Phenol	(D)	12-19	14	1-10	5	64.3
	(P)	0-640	176	0-250	41	76.7
Bis(2-Ethylhexyl)	(D)	2-22	9	3-38	14	55.5
Phthalate	(P)	0-200	29	0-91	21	27.6
Butyl Benzyl Phthalate	(D)	0	0	0-2	1	0
Di-n-Butyl Phthalate	(D)	0-2	1	0-1	1	0
	(P)	0-3	1	0	0	100
Diethyl Phthalate	(D)	0-9	9	0	0	100
	(P)	0-5	2	0-14	5	0
Anthracene	(D)	0	0	0-1	1	0
Tetrachloroethylene	(P)	0	0	0-6	3	0
Toluene	(D)	0-1	1	0	0	100
	(P)	0-70	23	0-66	14	39.1
Trichloroethylene	(P)	2-33	15	0	0	100
Chromium	(D)	18-46	33	11-1100	285	0
	(P)	6-66	23	3-16	8	65.2
Copper	(D)	<8-35	17	6-28	20	0
	(P)	<2-220	71	8-100	33	53.5
Lead	(D)	11-25	16	0-30	15	6.3
	(P)	<2-86	25	<1-42	11	56
Mercury	(D)	<0.5	<0.5	<0.5	<0.5	--
	(P)	0.5-1.8	0.7	<0.5-1.5	0.7	0
Nickel	(D)	8-45	25	<2-269	130	0
	(P)	3-48	15	<2-18	9	40
Zinc	(D)	42-85	70	37-77	60	14.3
	(P)	5-150	104	25-420	118	0
Abietic Acid	(D)	94-5200	1949	0-940	383	80.3
	(P)	0-490	137	8-340	76	44.5
Dehydroabietic Acid	(D)	190-1870	1000	6-400	171	82.9
	(P)	2-1300	423	0-950	246	41.8

Table 25 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN SULFITE MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction
		Untreated	(Raw)	Treated	(Final)	
		Range	Average	Range	Average	
Isopimaric ACid	(D)	15-1760	774	0-230	115	85.1
	(P)	0-230	62	0-84	17	72.6
Pimaric Acid	(D)	180-450	277	20-38	31	88.8
	(P)	0-64	25	0-52	17	32
Oleic Acid	(D)	28-1860	1157	31-120	81	93
	(P)	14-330	129	0-220	70	45.7
Linoleic Acid	(D)	240-1000	510	0-25	8	98.4
	(P)	8-270	63	0-160	34	46.0
Linolenic Acid	(P)	0-130	58	0	0	100
Epoxystearic Acid	(P)	0-120	40	0-20	7	82.5
Chlorodehydroabietic Acid	(D)	45-360	161	0-241	108	32.9
	(P)	8-340	123	0-93	39	68.3
Dichlorodehydroabietic Acid	(D)	0-280	93	0	0	100
	(P)	0-5	2	0-3	1	100
Trichloroguaiacol	(D)	6	6	0	0	100
	(P)	2-6	4	0-3	2	100
Tetrachloroguaiacol	(D)	4	4	2	2	50
	(P)	0-2	1	0	0	100
Xylenes	(P)	0-4	1	0	0	100
Color	(D)	1070-2600[a]	1506	850-3600[a]	1668	55.6
	(P)	14-7100[a]	3046	<5-3150[a]	1500	99.5
Ammonia	(D)	6.2-24.3[b]	12	3.45-9.5[b]	7	41.7
	(P)	0-250[b]	105	6.8-48[b]	21	80
COD	(D)	1744-3170[b]	2251	1040-2170[b]	1404	37.6
	(P)	780-8700[b]	4901	690-2370[b]	1342	72.6

Subcategory Key:
D - Dissolving
P - Papergrading

[a] Color concentrations given in platinum cobalt units
[b] Ammonia and COD concentrations given in mg/l

Although similarities exist between sulfite and kraft processing, air pollutants generated by each are quite different, since sulfur dioxide is the principal air contaminant generated by sulfite pulping. This pollutant is derived mainly from the absorption towers used in producing the acidic cooking liquor, where SO_2 is reacted with the desired base chemical (Ca, Mg, NH_4, Na), and in the blow pit or dump tank, multiple effect evaporators and chemical recovery systems. The amount of SO_2 emitted from sulfite pulping depends on the pH level of the cooking liquor, as well as the design and operating conditions of the absorption towers. The range of SO_2 emissions from various process components of sulfite pulp mills is illustrated in Table 26. The general treatment for SO_2 emissions, which usually exceeds 90% efficiency, is scrubbing with alkaline solutions.

Table 26 SULFUR DIOXIDE EMISSIONS FROM SULFITE MILL PROCESS COMPONENTS

Process Component	kg/kkg of Pulp
Blow Pit (Hot Blow)	30-75
(Cold Blow)	2-10
Evaporators	1-30
Recovery Process	80-250
Washers	0.5-1
Acid Preparation	0.5-1

Solid wastes from sulfite pulping typically include bark, rejects and screenings, ash, and waste paper, as well as some inert materials and some oxides of the base cooking chemical generated in the chemical recovery system. Total solid waste generation averages about 5 kg/kkg of pulp production (5). In some cases, portions of these solid wastes are generated in the waste water system for removal rather than segrated for separate collection.

NEUTRAL SULFITE SEMI-CHEMICAL (NSSC) PULP PROCESSING (STUDY AREA 5)

Semi-chemical pulping incorporates some of the characteristics of both chemical and mechanical pulping (a discussion of mechanical pulping is presented later in this section). NSSC is described as a "neutral sulfite" since the liquor utilized is neutral or slightly alkaline (pH 7-9) by comparison to other chemical pulping processes. In Figure 15, a generalized NSSC flow diagram is presented. Process control measures applicable to NSSC operations, intended to improve process efficiencies and reduce waste loadings, are located on this diagram and are presented in Table 27. These process controls are further discussed in Appendix B. Table 28 presents a listing of the major chemicals used in NSSC processing. No data are available to quantify the occurrences of these chemicals relative to the amount of pulp produced.

The cooking liquor is commonly prepared by burning sulfur to sulfur dioxide and absorbing the latter in soda ash or ammonia. The major reasons for selecting sodium as the base are (16):

- The use of this base is a well proven measure.
- It provides high quality products and high yields.
- It can utilize a wide variety of hardwoods.
- It can also utilize softwoods, including sawdust and other wastes.
- It does not involve handling gases other than SO_2, to which the industry is accustomed.

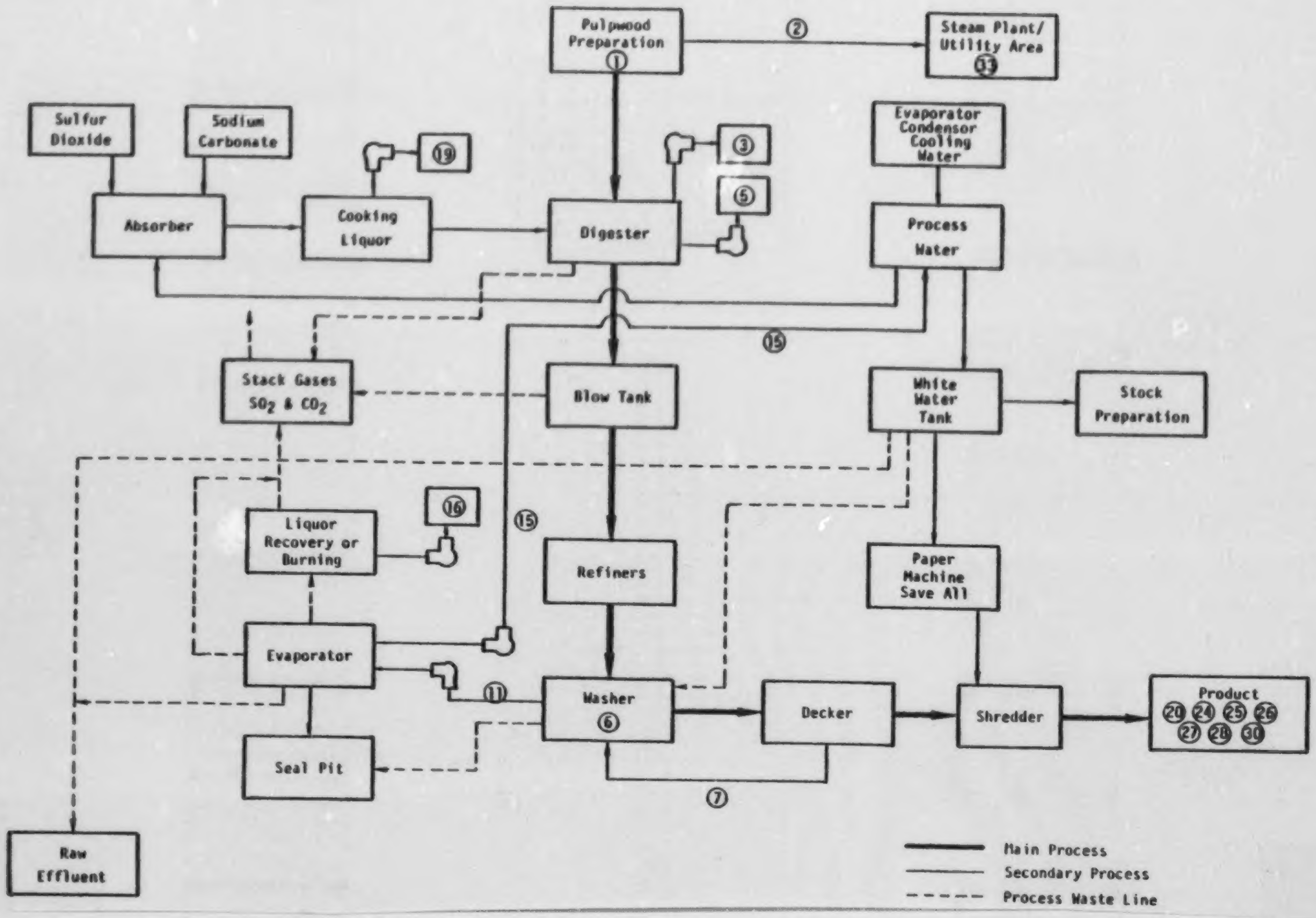


Figure 15 NSSC Pulp Mill Process Flow Diagram

Table 27 NSSC PROCESS CONTROL MEASURES

Process Area		Control Technology Description	Semi-Chemical	Unbleached Kraft Cross Recovery
Pulpwood Preparation	1	Close-up or dry woodyard and barking operation	●	●
	2	Segregate cooling water	●	●
Pulp Mill	3	Reuse blow condensates	●	
	5	Spill collection	●	●
Washers & Screen Room	6	Add third stage washer	●	●
	7	Reuse decker filtrate	●	●
Evaporator/Recovery Area	11	Reuse Evaporator condensate		●
	15	Segregate cooling water	●	●
	16	Spill collection	●	●
Liquor Preparation Area	19	Spill collection		●
Papermaking	20	Paper machines/bleached pulp spill collection	●	
	24	Paper maching white water showers for wire cleaning		●
	25	White water storage for upsets and pulper dilution		●
	26	Recycle press water	●	●
	27	Reuse of vacuum pump water	●	●
	28	Broke storage	●	●
	30	Segregate cooling water	●	●
Steam Plant/Utility Areas	33	Segregate cooling water	●	●

Table 28 NSSC PULP PROCESS CHEMICALS

Chemical	Use
Sodium Carbonate (Soda Ash)	Sodium base cooking chemical
Ammonia	Ammonia base cooking chemical
Sulfur Dioxide	Used in cooking liquor and absorbed by base: obtained by burning sulfur
Sulfur	Burned to obtain sulfur dioxide

- Air and water pollution problems are minimized since the sodium base can be recovered.

- The use of sodium permits integration with a kraft mill and, thus, a cross recovery system.

The major reasons for selecting ammonia as the base are (17):

- Although pulp of similar quality and yield to that of sodium base NSSC can be achieved with an ammonia base, ammonia is relatively cheap and is readily available in many areas.
- The spent liquor is more readily combustible than sodium base liquor.
- It can be incinerated to a nearly ash-free product.

In this process, chips are impregnated with cooking liquor, subjected to a short cook and mechanically refined. Bleaching NSSC pulp is achieved in essentially the same manner as that described for sulfite pulps.

Wood chips are cooked at high temperatures for a period of about 10 to 20 minutes or at lower temperatures for longer periods of time (generally, one to three hours). After cooking, the softened chips are sometimes compressed in one or more stages of screw pressing to maximize the recovery of spent liquor. The cooked chips are then transferred to a disc mill for fiberization. The chips then undergo vacuum or pressure washing and screening and/or centrifugal cleaning. The pulp is conveyed to an agitator (shredder) chest where it is diluted with white water from the paper mill.

Chemical recovery in the sodium-based NSSC process is considerably more difficult than in the kraft process. The spent liquor is low in solids and does not burn easily. At many mills, spent liquor is evaporated and burned without recovery of the chemical base (16). Evaporation is commonly accomplished in multiple-effect evaporators. The concentrated liquor is burned for disposal or recovery in a fluidized bed reactor or a specially designed furnace. In sodium-base mills, the fluidized bed combustion units produce sodium sulfate which is suitable for use in kraft mill liquor systems. No successful system has been developed for ammonia recovery at ammonia-base NSSC mills; the spent liquor is simply incinerated to recover energy.

The non-sulfur semi-chemical processes allow for recovery of soda ash after burning of spent liquor in a modified kraft-type furnace or fluidized bed. The recovered chemical is recycled to the digester; caustic make-up provides a balanced pH for liquor reuse. In any semi-chemical recovery system, evaporator condensate may be sewered.

Some kraft paper mills have an accessory sodium-base neutral sulfite semi-chemical pulp mill. In most instances, these are areas where appreciable hardwood species grow as well. These mixed hardwoods are harvested separately but simultaneously with the pine, cooked by the sodium base NSSC process, and manufactured into corrugating board.

Kraft recovery systems can absorb spent liquor from an NSSC mill producing about one-third the tonnage of the kraft operation, assuming that adequate evaporator capacity is provided to accept the NSSC brown liquor, which is generally more dilute and lower in heat value than the kraft black liquor. Problems which have been encountered in handling NSSC spent liquor in kraft recovery plants are as follows (17):

- The low solids content of NSSC liquor which dilutes kraft black liquor to a degree where considerable additional evaporator capacity and steam is required.

- The lower heat value of NSSC liquor solids which requires evaporation of combined liquors to a higher consistency, making forced feed necessary in the final evaporation effects due to higher liquor viscosity.

- Increased evaporator fouling and scaling problems and the need for frequent boil-out.

- Corrosion problems resulting from the presence of NSSC liquor components in the system.

The raw waste load from NSSC mills depends largely on the three following factors:

- Base used (sodium or ammonia)
- Whether chemical recovery is employed
- The amount of waste paper added to the furnish

In Table 29, the effects of furnish and waste liquor handling on sodium base NSSC effluents are presented.

Table 29 THE EFFECTS OF FURNISH AND WASTE LIQUOR HANDLING ON SODIUM BASE NSSC EFFLUENTS (5)

Liquor Handling	Flow kl/kkg	Waste Paper Furnish (%)	BOD_5 kg/kkg	TSS kg/kkg
Spray Irrigation	44.6	33	8.5	8.5
Evaporation and Incineration	48.8	6	31.0	17.5
		33	35.0	
		27-37	24.0	
		17-21	31.0	

The major difference in waste water characteristics of sodium base and ammonia base mills is the nitrogen content of ammonia base effluents. Typical nitrogen values for an ammonia base effluent are 210 mg/l Kjeldahl nitrogen and 150 mg/l ammonia nitrogen (5). Only minor amounts of nitrogen are contained in sodium base effluents. In Table 30, effluent characteristics of sodium base, ammonia base and NSSC mills with unbleached kraft cross-recovery are presented. As seen in this table, variations in effluent characteristics among these mill types are not significant. In kraft cross-recovery mills, the NSSC contribution to the combined effluent does not settle as well as kraft effluent alone because of the higher load of fines in NSSC effluent. Hardwoods used in NSSC mills also contribute somewhat more color than the softwoods used in the kraft mill.

Table 30 EFFLUENT CHARACTERISTICS OF NSSC PROCESSES

		BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Sodium Base	(Range)	1.3-75	0.2-55	7.1-107
	(Mean)	24	26	30
Ammonia Base	(Range)	31-34	17-19	27-35
	(Mean)	--	--	--
Kraft Cross Recovery	(Range)	8.8-43	9.7-38	31-74
	(Mean)	19	21	58

Although extensive internal recycling has succeeded in reducing flow and BOD loadings to very low levels in some NSSC mills, this performance can not be maintained because of an intolerable build up of spent cooking liquor in the final product (5). Thus, the high degree of recycling commonly practiced is frequently accompanied by high BOD losses.

In Table 31, priority and nonconventional pollutants analyzed in NSSC mill effluent stream are presented for mills operating with and without unbleached kraft cross-recovery. Pure NSSC mills, those using sodium and ammonia base, are combined in this table. Effluent treatment at all these mills is biological. For a more indepth discussion of the various biological treatments which may be employed at NSSC mills and other mills in the industry, see Appendix C.

Sulfur dioxide is the primary air contaminant generated by NSSC mills and occurs principally when pulp is blown from the digester. Sulfur dioxide emissions also result from the burning of ammonia base spent liquors, a water pollution control measure. The NSSC process is virtually free of reduced sulfur compound emissions.

Solid wastes generated by NSSC mills include bark, rejects and screenings, chemical ash from bark incinerators and chemical combustion and waste paper. No data are available on typical quantities of these materials.

Table 31 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN NSSC MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction
		Untreated (Raw)		Treated (Final)		
		Range	Average	Range	Average	
Benzene	(SC)	5-6	5	0-3	2	60
	(UK)	1-5	3	0	0	100
1,1,1-Trichloroethane	(UK)	3-7	5	0	0	100
Chloroform	(SC)	1-4	2	0	0	100
	(UK)	0-6	3	0	0	100
Ethylbenzene	(SC)	0-2	1	0-2	1	0
Methylene Chloride	(SC)	0-21	6	1-14	5	16.7
	(UK)	0-220	58	0-80	13	77.6
Naphthalene	(SC)	0-5	3	0	0	100
Pentachlorophenol	(SC)	0-5	2	0-2	1	50
	(UK)	0-7	2	0	0	100
Phenol	(SC)	160-400	230	3-24	14	93.9
	(UK)	30-100	56	0	0	100
Bis(2-Ethylhexyl) Phthalate	(SC)	0-46	21	3-29	15	28.6
	(UK)	0-16	10	0-14	10	0
Butyl Benzyl Phthalate	(SC)	0-1	1	0	0	100
Di-n-Butyl Phthalate	(SC)	1-11	4	0	0	100
	(UK)	0-12	5	0	0	100
Diethyl Phthalate	(UK)	0-20	13	0	0	100
Toluene	(SC)	3-7	5	1-4	2	60
	(UK)	2-4	3	0	0	100
Trichloroethylene	(SC)	4-15	9	0	0	100
	(UK)	0-3	1	0	0	100
PCB-1254	(UK)	0-<1	1	0-2	1	0
Chromium	(SC)	18-42	29	16-23	19	34.5
	(UK)	8-76	29	8-47	19	34.5
Copper	(SC)	44-120	79	5-37	25	68.4
	(UK)	16-64	38	2-28	15	62.5
Cyanide	(SC)	<10	<10	<10	<10	--
	(UK)	<10-25	15	<10-15	11	26.7
Lead	(SC)	47-131	95	22-50	35	63.2
	(UK)	9-42	24	<2-24	13	45.8
Mercury	(SC)	<0.5-0.6	0.5	<0.5	<0.5	--
	(UK)	<0.5	<0.5	0-<0.5	<0.5	--
Nickel	(SC)	<2-22	12	6-17	10	16.7
	(UK)	<2-29	10	<2-12	5	100
Zinc	(SC)	78-230	143	31-120	69	51.7
	(UK)	24-58	40	15-46	25	37.5
Abietic Acid	(SC)	220-290	257	35-43	39	84.8
	(UK)	650-2000	1392	580-1000	710	94.9
Dehydroabietic Acid	(SC)	79-230	168	0-27	14	91.7
	(UK)	230-1000	607	200-330	235	61.3
Isopimaric Acid	(SC)	23-48	34	0-16	7	79.4
	(UK)	260-850	547	140-260	187	65.8
Pimaric Acid	(SC)	0-130	36	0-13	4	88.9
	(UK)	37-370	152	39-190	106	30.3
Oleic Acid	(SC)	21-200	115	0-56	33	71.3
	(UK)	210-1200	618	130-800	407	34.1

Table 31 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN NSSC MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction
		Untreated (Raw)		Treated (Final)		
		Range	Average	Range	Average	
Linoleic Acid	(SC)	66-160	122	13-17	14	88.5
	(UK)	98-820	441	0-170	59	86.6
Linolenic Acid	(SC)	54-140	98	31-39	35	64.3
Epoxystearic Acid	(UK)	99-380	266	0-190	113	57.5
Chlorodehydroabietic Acid	(SC)	0	0	3-18	9	0
Dichlorodehydroabietic Acid	(SC)	0	0	0-30	13	0
Xylenes	(SC)	0-4	2	1-3	2	0
	(UK)	19-27	22	0	0	100
Color	(SC)	1820-8000[a]	3915	2350-6400[a]	3825	2.3
	(UK)	200-1080[a]	425	170-390[a]	258	39.3
COD	(SC)	1940-2820[b]	2410	1055-1930[b]	1493	38
	(UK)	648-1296[b]	897	80-464[b]	310	65.4

Subcategory Key: SC - Semi-Chemical
UK - Unbleached Kraft Cross Recovery

[a] Color concentrations given in platinum cobalt units
[b] COD concentrations given in mg/l

MECHANICAL (GROUNDWOOD) PULP PROCESSING (STUDY AREA 6)

For this discussion, mechanical pulping is segmented into the following four categories:

- Chemi-Mechanical
- Thermo-Mechanical
- Course, Molded, Newsprint (CMN)
- Fine Papers

In chemi-mechanical pulping, short lengths of logs called billets are first pressure impregnated with a dilute solution of sodium sulfite before grinding. In another variation of chemi-mechanical pulping, cold soda pulping, chips are steamed in a caustic solution before refining. In thermo-mechanical pulping, chips are first softened with heat and sometimes chemicals, then refined under pressure. The CMN and fine papers subcategories involve the basic mechanical pulping process, in which pulp is made by grinding billets on a grind stone; further refining of groundwood is achieved by passing wood chips through a disc refiner.

The basic mechanical pulping process is illustrated in Figure 16. Process control measures which are commonly employed in mechanical pulping are numbered on this flow diagram and are presented in Table 32. An in-depth discussion of these process control measures is presented in Appendix B. In Table 33, chemicals commonly used during the pulping and bleaching of mechanical pulps are presented.

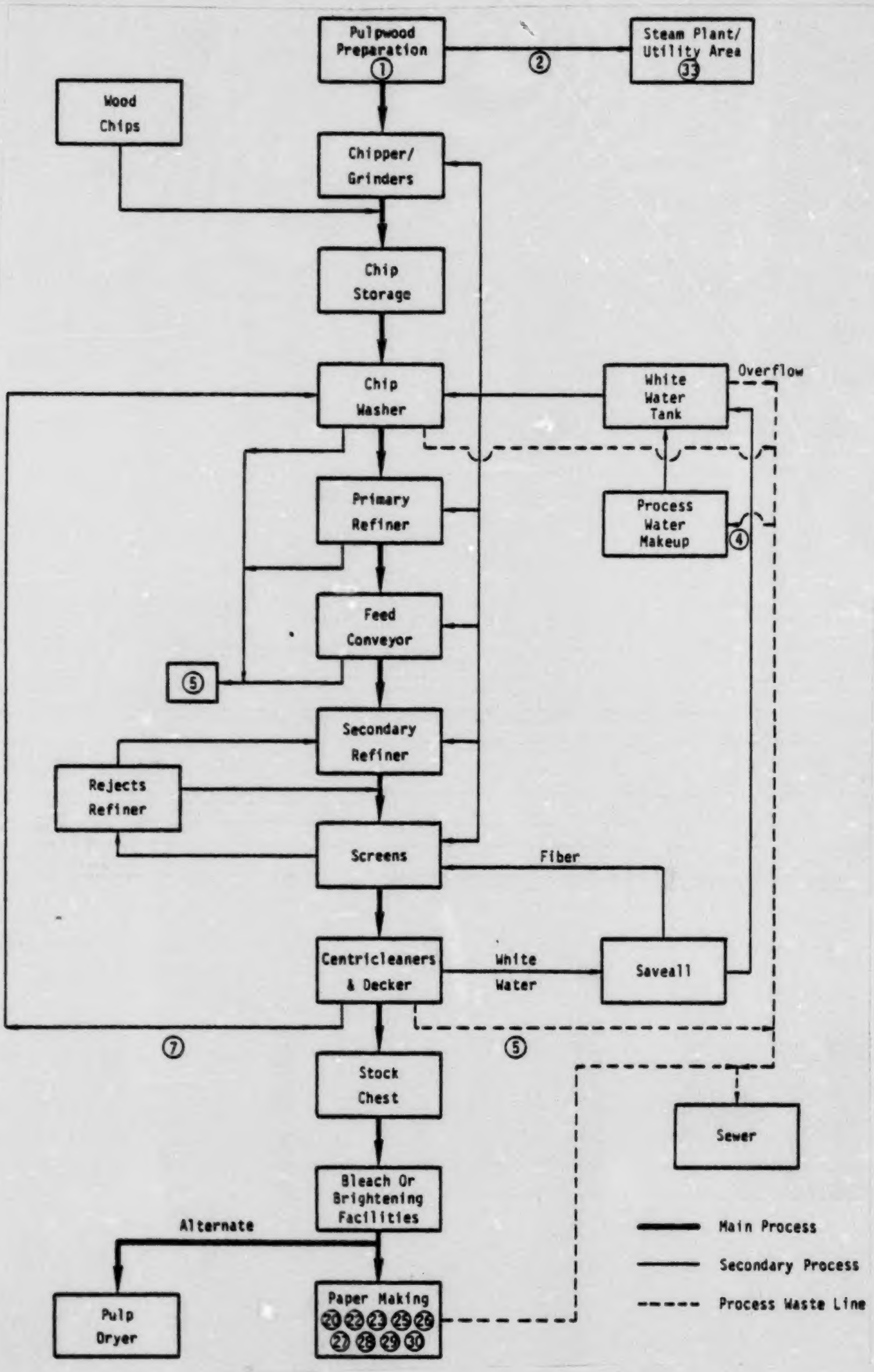


Figure 16 Mechanical Pulp Mill Process Flow Diagram

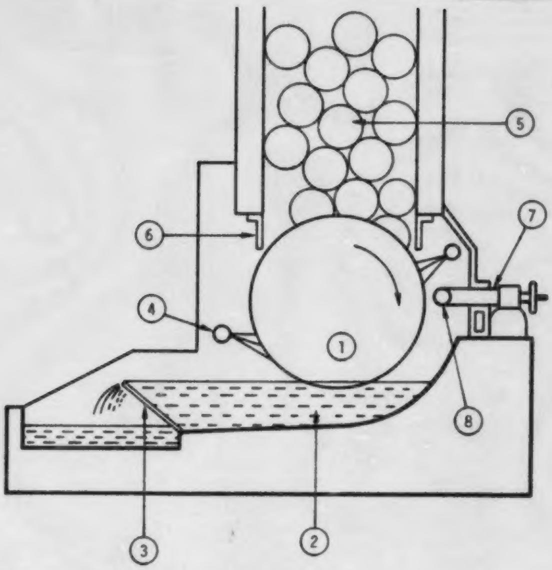
Table 32 MECHANICAL PULPING PROCESS CONTROL MEASURES

Process Area		Control Technology Description	Subcategories		
			Thermo-Mechanical (TMP)	Course,Molded Newsprint (CMN)	Fine Papers
Pulpwood Preparation	1	Close-up or dry wood yard and barking operation	●		●
Pulp Mill	2	Segregate cooling water	●	●	●
	4	Reduce groundwood thickener overflow			●
	5	Spill collection	●	●	●
Washers and Screen Room	7	Decker filtrate reuse		●	
Paper Mill	20	Spill collection: paper machine bleached pulp	●	●	●
	20	Spill collection: color plant			●
	22	High pressure showers for wire and felt cleaning	●	●	●
	23	White water use for vacuum pump sealing		●	●
	25	White water storage for upsets and pulper dilution	●	●	●
	26	Recycle press water		●	●
	27	Reuse vacuum pump water		●	●
	28	Broke storage		●	
	29	Wet lap machine	●	●	●
	30	Segregate cooling water		●	●
Steam Plant and Utility Areas	33	Segregate cooling water			●

Table 33 MECHANICAL PULPING AND BLEACHING PROCESS CHEMICALS

Chemical	Use	kg/kkg of Product
Sodium Carbonate	Cold-soda pulping	18-45
Sulfur	Chemi-mechanical pulping	2.5-5
Sodium Sulfite	Chemi-mechanical pulping	
Sodium Hydroxide	Chemi-mechanical pulping Peroxide bleaching pH stabilizer	
Sodium Dithionite	Reductive Bleaching	
Sodium Bisulfite	Reductive Bleaching	
Zinc Dithionite	Alternative Dithionite	
Sulfur Dioxide	Aqueous mix with zinc to form dithioniteperioxide bleaching to prevent color reversion	
Di- or Tetrasodium Ethylenediamine Tetraacetate	Sequestering agent in dithionite bleaching	
Pentasodium Diethylenetriamine Pentaacetate	Sequestering agent in dithionite and peroxide bleaching	
Nitrilotriacetic Acid	Sequestering agent in dithionite bleaching	
Sodium Tripolyphosphate	Sequestering agent in dithionite bleaching	
Hydrogen Peroxide	Oxidative bleaching	
Sodium Peroxide	Alternative peroxide	
Magnesium Sulfate	Peroxide bleaching input	
Sodium Silicate	Peroxide bleaching input	
Sulfamic Acid	Peroxide bleaching input	
Trisodium-2-Hydroxyethyl Ethylenediamine Triacetate	Sequestering agent in peroxide bleaching	
Sulfuric Acid bleaching	pH control in sodium peroxide	

In the basic mechanical pulping process, billets are fed to grinders by hand or automatically from a belt or chair conveyor and are forced hydraulically against large rotating grindstones specifically designed for the purpose, as illustrated in Figure 17. The grinding occurs in the presence of a large quantity of water that acts as both a coolant and a carrier to slice the pulp from the body of the grinder. The pulp slurry is diluted to a consistency of from 0.6% to 0.8% and is passed through coarse and fine screens and a centri-cleaner to remove dirt and shives. Oversize rejects may be passed through a disc refiner and returned to the system ahead of the fine screens.



1. Stone; 2. pit; 3. dam; 4. shower; 5. wood magazine; 6. finger bars; 7. sharpening lathe; 8. burr

Figure 17 Arrangement of Groundwood Grinder

Thermo-mechanical pulping is a mechanical process in which wood chips, sawdust and/or wood shavings are steamed for a short time at 165° to 185°C to soften the interfiber lignin and partially separate the fibers. The pulp is then refined in disc refiners (as shown in Figure 18) coupled to the steaming vessel; the pulp may also be cooled to 100°C and refined in "atmospheric" refiners.

The major items of equipment are the steamer and the refiner. Horizontal or vertical steaming tubes may be used with rotary screws carrying chips through the vessel and feeding the refiners through blow lines and cyclones.

In chemi-mechanical pulping, the liquor used contains from 60 to 180 mg/l of sodium sulfite buffered with one-sixth to a third of that amount of soda ash. Hardwood billets are first impregnated with liquor and then cooked for periods ranging from a half hour to six hours at a maximum temperature of 135 to 150°C. This is followed by grinding on stones under operating conditions very similar to those of stone groundwood. This pulp is stronger than conventional groundwood (15).

In the production of cold soda pulp, chips are soaked either at atmospheric pressure for two hours or under forced pressure for shorter periods of time in liquor containing 20 to 40 mg/l of caustic soda. The caustic expended varies from 2% to 10% of the weight of the wood depending on the wood species used and the pulp quality desired. The liquor is recycled after fortification. Subsequent separation of chips and liquor may be accomplished by gravity or screw or roll presses may be employed. The treated chips are then handled in a manner similar to that used in manufacturing refiner groundwood (15).

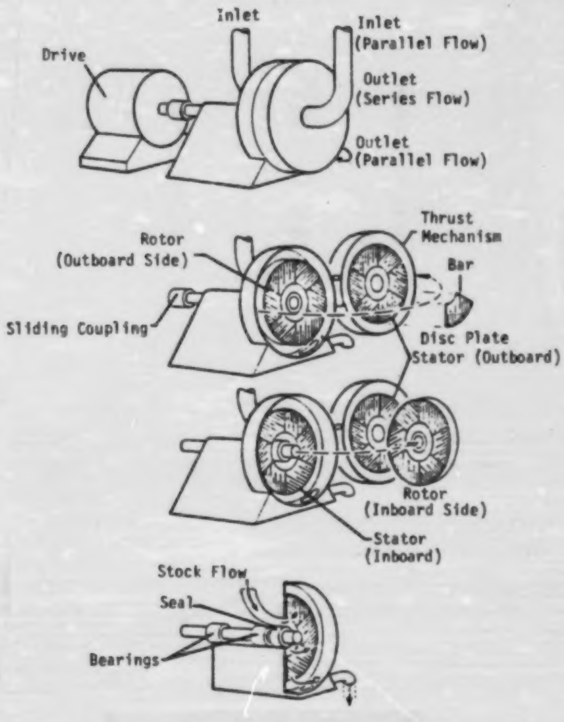


Figure 18 Disc Refiner (Simplified Representation)

While purely mechanical pulps have many desirable qualities for the manufacture of low-cost papers, they are not naturally sufficently bright for the better grades. Brightness also varies with the characteristics of the wood raw material. For example, northeastern spruce and balsam will generally produce a ground pulp in the brightness range of 57 to 65 units while pulps from west coast species such as western hemlock range in the low 50's. Thus, bleaching is undertaken when necessary to satisfy the demands of various end products (10).

The most common bleaching agents used for stone and refiner groundwood are hydrosulfites and peroxides, and, in some cases, both are used sequentially as shown in Figure 19. Hydrosulfite systems can improve brightness by as much as 8 to 12 standard brightness units in a single stage operation and up to 15 to 20 units in a two-stage operation with peroxide. Peroxide alone has capabilities in the range of 8 to 12 or more units.

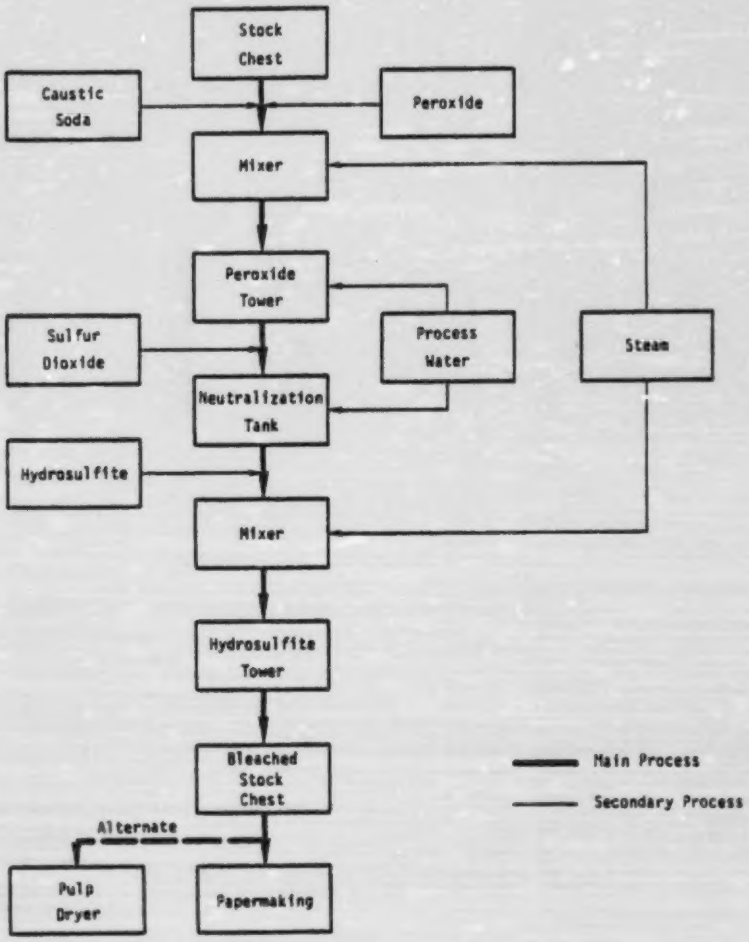


Figure 19 Mechanical Pulp Bleach Plant Process Flow Diagram

In peroxide bleaching, hydrogen peroxide is generally used, although sodium peroxide is sometimes employed. A solution of from 0.5% to 1.5% hydrogen peroxide or its oxygen equivalent of sodium peroxide is applied to the pulp. Frequently a small amount of magnesium sulfate (0.24 to 0.48 g/l of bleach solution) is used for stabilization purposes. The pH of the pulp is first adjusted to 10.5 with caustic soda, which requires from 1.0% to 3.0% NaOH. Sodium silicate or sulfamic acid sometimes replaces the caustic soda since they are capable of sequestering metallic ions which catalyze peroxide decomposition or discolor the product. Groundwood pulp is generally bleached with peroxide at between 38° to 49°C. Consistencies of bleaching range from 4% to 35%. The pulp is usually subsequently neutralized with sulfur dioxide to prevent reversion.

In some instances, refiner groundwood is subjected to refiner bleaching, i.e., a solution of peroxide is added to the disc refiner employed for fiberizing. The bleaching reaction thus begins while the pulp is refined and is subsequently completed after discharge by maintaining the pulp at discharge temperature, 77° to 93°C, for about 15 minutes.

Some mills mix nodulated (pressed and shredded) pulp with sodium silicate and hydrogen peroxide in tank cars or truck tankers utilizing the tankage in transit as a reaction vessel for the bleaching operation.

Peroxide solutions are prepared at the mill by batch or continuous methods, and may contain either hydrogen or sodium peroxide or both. Magnesium sulfate, sodium silicate, sodium and/or hydrogen peroxide is replaced by caustic soda. In the case of sodium peroxide solution, sulfuric acid is used to replace the hydrogen peroxide.

When sodium or zinc dithionite (hydrosulfite) is used to bleach or brighten groundwood pulp, the chemical is frequently added directly to the secondary refiner or grinder sinks, canals, or stock chests since heat is important to the reaction. From 0.2% to 2.0% of the chemical is used depending upon the species of wood from which the pulp is derived and the desired brightness; a temperature of 49° to 50°C is most desirable at a consistency of 15% or greater. Sodium dithionite is now preferred because of zinc discharge limitations.

Dithionite solutions are prepared from purchased dithionite or from chemicals manufactured at the mill. In one method, zinc dithionite is made by reacting zinc dust with aqueous sulfur dioxide. In another, the zinc dust is mixed with pulp and sulfur dioxide is introduced in aqueous solution or as a gas. Dithionite can also be added dry at lower consistencies. Sodium and potassium borohydride, which also inhibit reversion following bleaching, are sometimes used for brightening groundwood pulp, but, because of the chemical costs involved, the use of these chemicals has not become established practice in this country. The cost of peracetic acid has similarly precluded its use for groundwood bleaching (15).

Due to the alkaline pretreatment they receive, cold soda pulps are darker than stone and refiner groundwood. However, the chemicals used to bleach these pulps are the same, except that calcium and sodium hypochlorites may also be used because of their amenability to hardwood. Single-stage treatment can produce a brightness of from 67 to 72. Seventy-five to 80 brightness units can be obtained from multi-stage bleaching.

Bleaching chemicals are generally applied in retention chests or towers, although peroxide can be added at the refining stage and hypochlorites during the steeping process. The latter applications require more chemical, however, to achieve a brightness equal to that attained by the use of towers, which can yield a brightness increase of 20 units with one-stage bleaching. When peroxide is used in the refiner it may be necessary to control the alkalinity of the pulp by adding sulfuric acid.

Chemi-groundwood pulp, which is characterized by low initial brightness (10), responds well to peroxide or hypochlorite bleaching. The processes used are very similar to those for the other types of groundwood pulp. One exception is that peroxide refiner bleaching is not appropriate for this pulp unless the residual sodium sulfite liquor is removed before peroxide is added. Even then it may be ineffective (15).

The effluent characteristics data presented in Table 34 is segmented into the four following subcategories:

- Chemi-mechanical pulping
- Thermo-mechanical pulping
- Coarse, molded, newsprint (CMN)
- Fine papers

Effluents from all these processes contain suspended solids and dissolved organic matter, both of which contribute to the BOD load. Chemi-mechanical process waters also contribute electrolytes containing some ions of the residual and spent chemicals. Dissolved organic materials in mechanical pulping effluents consist of wood sugars and cellulose degradation products, as well as resinous substance. Processes involving the use of chemical conditioning agents (chemi-mechanical) show the higher BOD values.

Table 34 EFFLUENT CHARACTERISTICS OF MECHANICAL PULP PROCESSING

Subcategory		BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Chemi-Mechanical	(Range)	87-105	23-81	104-121
	(Mean)	96	52	113
Thermo-Mechanical	(Range)	18-39	39-49	48-88
	(Mean)	29	40	74
Coarse, Molded, Newsprint	(Range)	10-23	21-98	47-180
	(Mean)	20	63	117
Fine Papers	(Range)	10-29	37-79	55-106
	(Mean)	18	54	101

In Table 35 priority and nonconventional pollutants in the analysis of fine papers mills effluent streams are presented where biological treatment systems are used to reduce the final effluent concentrations of these chemicals. An in-depth discussion of the biological treatment systems which are applied to mills in this study area is presented in Appendix C.

Traditionally, zinc hypochlorite has been used as a bleaching agent in mechanical pulping mills. A recent trend in new mills has been to replace the traditional zinc hypochlorite agent with other processes to avoid high effluent concentrations of zinc.

No data are available on air emissions from mechanical pulping processes. There is less potential for this type of problem than in full

Table 35 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN GROUNDWOOD (FINE PAPERS) MILL EFFLUENT STREAMS WITH BIOLOGICAL TREATMENT (1)

Chemical	Concentration (μg/l)				
	Untreated (Raw) Range	Untreated (Raw) Average	Treated (Final) Range	Treated (Final) Average	Percent Reduction
Chloroform	17-240	99	4-36	15	84.8
Ethylbenzene	0-3	1	0	0	100
Methylene Chloride	0-13	4	0	0	100
Pentachlorophenol	3-12	6	0-2	1	83.3
Phenol	15-51	28	0-5	2	92.9
Bis(2-Ethylhexyl)Phthalate	0-18	7	2-14	7	0
Di-n-Butyl Phthalate	0-8	3	0-11	4	0
Tetrachloroethylene	0-2	1	0	0	100
Toluene	1-63	13	0-2	1	92.3
Chromium	1-20	5	1-6	2	60
Copper	12-62	28	5-24	14	50
Lead	4-16	9	4-19	8	11.1
Mercury	0.5	0.5	0.5	0.5	--
Nickel	2-8	5	1-10	5	0
Zinc	53-90	74	9-86	45	39.2
Abietic Acid	11-600	182	0-26	7	96.2
Dehydroabietic Acid	28-360	148	10-50	26	82.4
Isopimaric Acid	0-110	29	0-6	3	89.7
Pimaric Acid	31-150	76	0-15	5	93.4
Oleic Acid	17-450	174	0-46	23	86.8
Linoleic Acid	180-620	337	11-150	72	78.6
Linolenic Acid	120-480	250	0	0	100
Color	5-300[a]	139	5-48[a]	21	84.9
COD	450-1020	625	77-200[b]	136	78.2

[a] Color concentrations given in platinum cobalt units (see Glossary for color)
[b] COD concentrations given in mg/l

chemical pulping processes. Even in those processes where chemicals are used, the harsh heat and pressure conditions of chemical pulping are avoided, although some volatile organic compounds may be expended.

Solid wastes from mechanical pulping mills consist typically of bark (if barking is performed on the premise), shives (small pieces of wood that will not grind properly), screenings, ash and waste paper.

WASTE PAPERBOARD PULP PROCESSING (STUDY AREA 7)

Waste paper is repulped mechanically as depicted in Figure 20. In this figure process control measures are labeled as they are presented in Table 36. These process control measures are discussed in-depth in Appendix B.

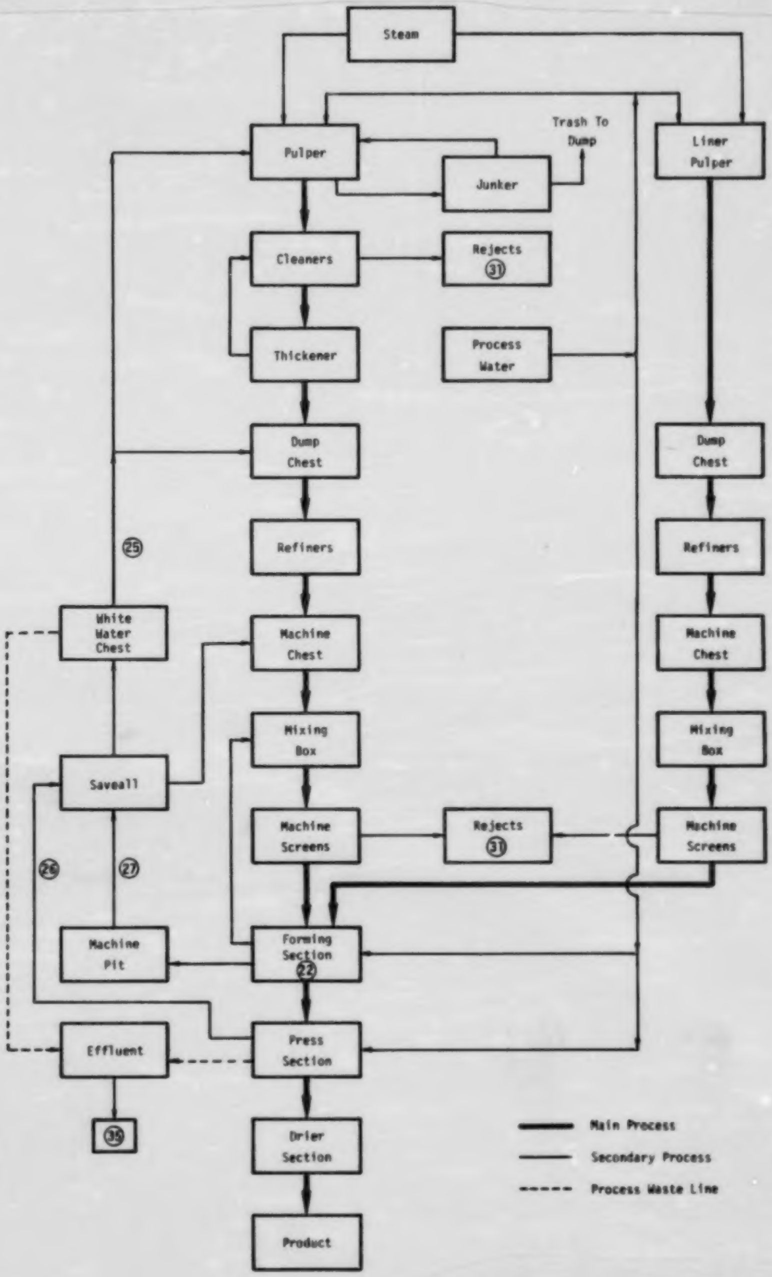


Figure 20 Waste Paperboard Pulp Process Flow Diagram

Table 36 WASTE PAPERBOARD PULP PROCESS CONTROL MEASURES

Process Component	Control Measure Description	
Saveall	21	Improve saveall
Forming Section	22	High pressure shower for wire and felt cleaning
White Water System	25	White water storage for upsets and pulper dilution
Press Section	26	Recycle press water
Machine Pit	27	Reuse of vacuum pump water
Screens/Cleaners	31	Cleaner rejects to landfill
Effluent/Clarifier	35	Recycle of effluent

The pulper in Figure 20 is designed to defiber waste paper into a slush. It consists of a tank or chest with rotors or other agitators. Chemicals are often introduced when it is necessary to remove ink. Deinking is carried out by heating the slurry in an alkaline solution, which is sometimes followed by chemical bleaching (a further discussion of this operation is given later in this section). The pulp is thoroughly washed and then blended with other pulp(s) to provide a furnish for paper- or boardmaking.

To convert waste paper to secondary fiber waste paper, sufficient water to provide desired consistency of 4% to 6% charged at a controlled rate to a pulper along with steam (17). In this operation, the paper follows water circulating in a large open vat and is repeatedly exposed to rotating impeller blades. Over a period of time, it is ripped, shredded, and finally defibered. The pulper operation may be batch, continuous, or a combination of both. A junker is usually attached which, through centrifugal action, collects and removes extraneous solid materials and paper not suitable for use.

The stock is then passed to centrifugal cleaners, and finally to a thickener which may be preceded by pressure screens. Reject material is dewatered for disposal, and the stock is stored for use or goes directly to the refiners which serve the paper machines.

The removal of modern contaminants found in waste paper (including plastic containers, polystyrene packing material, and other plastic coatings and laminants) has required some refinements to the basic process. Some mills also have systems for dispersing bituminous asphalt found in some reclaimed laminated kraft bags. This type system subjects the fiber to a heat and pressure environment in a press and digester (17).

The paper forming section of the board machine, or wet end, employed depends on the type of product made. Both fourdrinier and cylinder machines and some special devices are used. Variations and exceptions occur throughout the industry, although in general, a fourdrinier is used to make a single stock sheet and a cylinder machine for multi-ply sheet or heavy board. During recent years, cylinder machines have been replaced by variations of the so-called "dry-vat" principle in order to produce a multi-stock sheet at higher speeds. In the next section, a more detailed description of these machines is given.

The raw waste load of waste paperboard mills is generated in stock preparation area and is mainly a function of the type of raw materials and additivies used. In general, the higher the percentage of kraft or NSSC waste paper used in the furnish, the higher the BOD value per ton of product. Mills having wastes with higher BOD values generally employ an asphalt dispersion system in the stock preparation process in order to melt and disperse asphalt found in corrugated waste paper. As shown in Table 37, compiled data on waste paperboard effluents indicate a flow range from 2 to 139 kl/kkg; low values usually indicate a high degree of water recycling where coarse grade products (not foodboard products) are produced. If foodboard, which will be adversly affected by the accumulation of taste and odor producing substances, is not produced, the potential for water reuse is greater; water usage volumes should therefore be smaller. At waste paperboard mills where coarse grade products are produced, effluents may be nearly eliminated. The data on waste paperboard mills in Table 37 also show a range of TSS losses from approximately 3 to 81 kg/kkg. Residual pulping liquor, starch and other adhesives account for most of the BOD.

The waste water reclamation process has a unique solid waste generation problem in many mills where waste paper contaminants must be removed before new paper and paperboard products can be manufactured from available fiber. The highly diversified contaminants include glass, plastics and other heterogeneous materials. The extent of contamination varies with each batch of waste paper and each specific end use. Mills using mixed waste paper to produce lower grade products, for example, will generate more solid waste than mills using high grade segregated waste paper. No data are available to quantify the occurrences of these wastes.

Table 37 EFFLUENT CHARACTERISTICS OF WASTE PAPERBOARD PULP PROCESSING

	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Range	3.5-43	2.9-81	2.1-139
Mean	8.9	14	31

In Table 38, the results of an analysis to measure priority and nonconventional pollutants in waste paperboard processing effluent streams is presented for plants using both primary and biological effluent treatment systems. In Appendix C, a more indepth discussion of specific primary and biological treatment types is presented.

Table 38 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN WASTE PAPERBOARD PULP PROCESSING EFFLUENT STREAMS (1)

Chemical	Concentration (μg/l)				Percent Reduction	Treatment Type
	Untreated (Raw)		Treated (Final)			
	Range	Average	Range	Average		
Benzene	0-1	1	0	0	100	Biological
	0	0	0-3	1	0	Primary
1,1,1-Trichloroethane	0-4	2	0	0	100	Biological
	0-5	2	2-4	3	0	Primary
2,4,6-Trichlorophenol	0-5	2	0-6	1	50	Biological
	270-420	360	420-450	430	0	Primary
Chloroform	0-40	15	0-20	4	73.3	Biological
	0	0	0	0	--	Primary
Methylene Chloride	0-4	2	0-4	1	50	Biological
	0	0	3-142	50	0	Primary
Bromoform	0	0	0	0	--	Biological
	0-119	40	0-62	21	47.5	Primary
Dichlorobromomethane	0	0	0	0	--	Biological
	0-3	1	1-2	1	0	Primary
Pentachlorophenol	0-19	6	0	0	100	Biological
	850-1200	1050	1100-1400	1200	0	Primary
Phenol	430-500	457	310-520	427	6.6	Primary
	6-91	41	0-31	1	97.6	Biological
Bis(2-Ethylhexyl)Phthalate	17-34	23	0-20	7	69.6	Primary
	0-83	14	0-1200	87	0	Biological
Butyl Benzyl Phthalate	17-190	80	38-81	63	21.3	Primary
	0-170	51	0	0	100	Biological
Di-n-Butyl Phthalate	0-85	32	30-55	44	0	Primary
	0-21	9	0	0	100	Biological
Diethyl Phthalate	12-210	79	220-320	273	0	Primary
	38-690	234	0-310	71	69.7	Biological
Tetrachloroethylene	0-3	1	0	0	100	Biological
	0	0	0	0	--	Primary
Toluene	0-39	10	0-5	2	80	Biological
	1-6	4	2-5	3	25	Primary
Trichloroethylene	0-5	1	0	0	100	Biological
	0	0	0	0	--	Primary
PCB-1254	0-<1	<1	0-<1	<1	--	Biological
	0-<1	<1	<1	<1	--	Primary
PCB-1248	0-10	5	0-<1	<1	>80	Biological
	0	0	0	0	--	Primary
Chromium	<2-870	90	<2-17	8	91.1	Biological
	180-280	230	150-195	165	28.3	Primary
Copper	2-650	96	<2-42	15	84.4	Biological
	150-188	169	143-162	152	10.1	Primary
Cyanide	<10-143	27	<10-34	14	48.1	Biological
	29-155	74	<10-25	18	75.7	Primary
Lead	<2-900	137	<2-140	23	83.2	Biological
	135-230	198	60-130	92	53.5	Primary
Mercury	<0.5	<0.5	<0.5	<0.5	--	Primary
	<0.5-1	0.6	<0.5-2.2	0.7	0	Biological
Nickel	42-139	84	33-69	56	33.3	Primary
	<2-130	37	<2-44	14	62.2	Biological
Zinc	1100-1600	1433	1000-1900	1500	0	Primary
	26-4720	1206	40-210	113	90.6	Biological

Table 38 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN WASTE PAPERBOARD PULP PROCESSING EFFLUENT STREAMS (1)

Chemical	Concentration (µg/l)				Percent Reduction	Treatment Type
	Untreated	(Raw)	Treated	(Final)		
	Range	Average	Range	Average		
Abietic Acid	18-1900	651	0-96	19	97.1	Biological
	120-710	407	0	0	100	Primary
Dehydroabietic Acid	130-920	479	0-140	55	88.5	Biological
	410-530	467	59-120	96	79.4	Primary
Isopimaric Acid	12-600	128	0-15	3	97.7	Biological
	65-100	84	0-23	8	90.5	Primary
Pimaric Acid	0-210	78	0	0	100	Biological
	35-48	41	0	0	100	Primary
Oleic Acid	34-940	339	0-310	78	77	Biological
	180-450	290	0	0	100	Primary
Linoleic Acid	0-87	63	0	0	100	Biological
	0	0	0	0	--	Primary
Linolenic Acid	55-83	69	0-14	5	92.8	Biological
	0	0	0	0	--	Primary
Epoxystearic Acid	310-490	413	0	0	100	Biological
	0	0	0	0	--	Primary
Xylenes	0-6	3	0	0	100	Biological
	0-3	1	0	0	100	Primary
Color	<5-570[a]	159	<5-200[a]	86	45.9	Biological
	950-970[a]	960	880-970[a]	897	6.6	Primary
COD	164-6400[b]	1333	5-540[b]	201	84.9	Biological
	8440-9060[b]	8833	2980-8320[b]	4797	45.7	Primary

[a] Color concentrations given in platinum cobalt units
[b] COD concentrations given in mg/l

DEINK PULP PROCESSING (STUDY AREA 8)

The deinking process used to produce pulp for fine papers depends on the characteristics of the waste paper. The process consists primarily of an alkaline cook to which dispersants, detergents, and solvents are added. The process is essentially a laundering operation in which the sizes, any coating binder, and the pigment vehicle in the ink are dissolved or dispersed and the ink pigment released, along with filler and coating agents such as clay, calcium carbonate, and titanium dioxide. Adhesives such as starch and glue are also dissolved and dispersed. The process is essentially the same in all mills except that somewhat different process units may be used from a variety of specific pieces of equipment (15).

A process flow diagram for a deinking operation is presented in Figure 21. In this figure, deink process control measures are labeled. These measures are presented in Table 39. In Appendix B these process control measures are further described.

Waste paper is generally cooked in the pulper at a consistency of between 5% and 8% and a temperature ranging from 80° to 99°C. Cooking time is determined generally by examination of a sample from the pulper. During this step, a trash boot and a ragger may be used to remove trash, rags, rope,

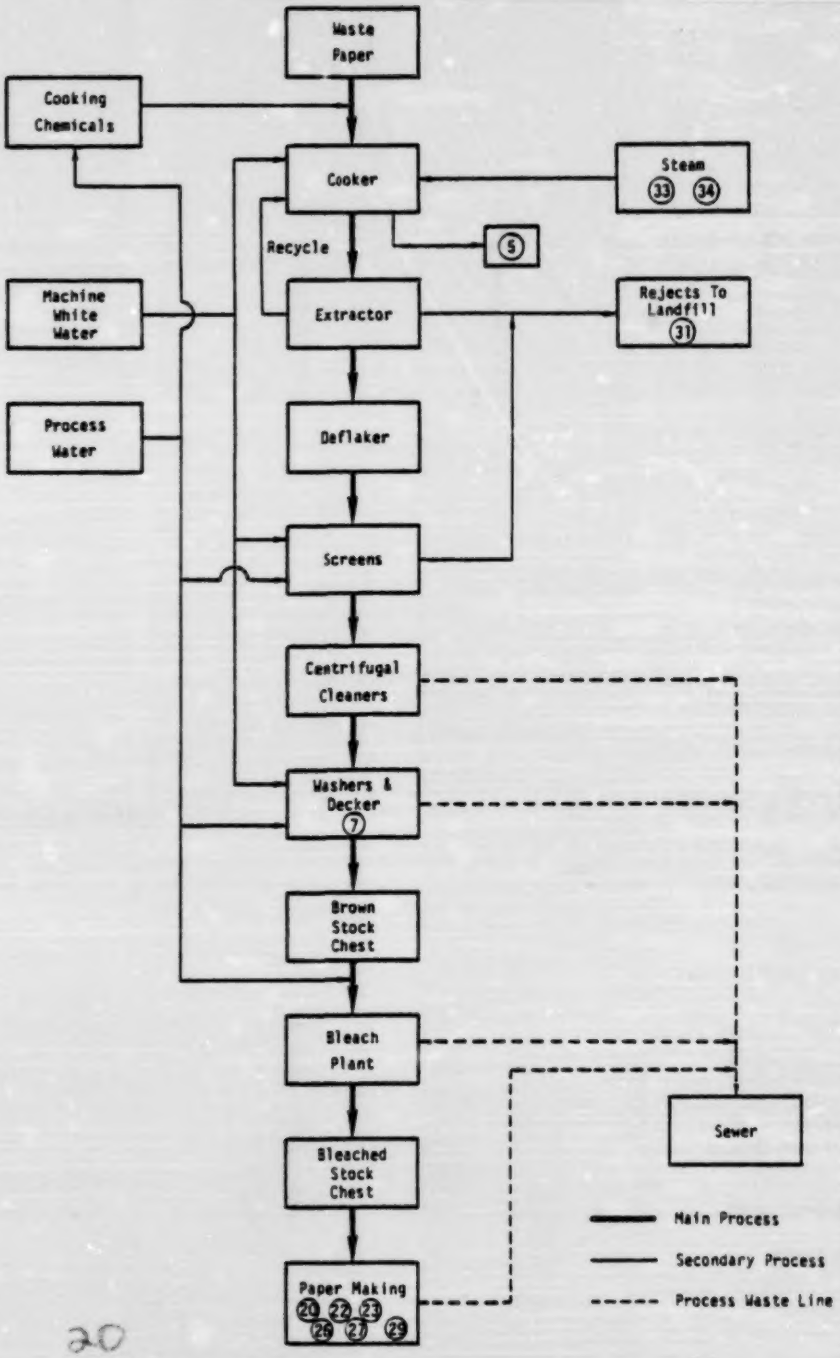


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Figure 21 Deinking Plant Process Flow Diagram

Table 39 DEINKING PROCESS CONTROL MEASURES

Process Area	Control Measure Description	
Cooker	5	Spill collection
Washers and Screen Room	7	Decker filtrate reuse
Paper Mill	20	Spill collection: paper machine and bleached pulp
	22	High pressure showers for wire and felt cleaning
	23	White water use for vacuum pump sealing
	26	Recycle press water
	27	Reuse of vacuum pump water
	29	Wet lap machine
	31	Rejects to landfill
Steam Plant and Utility Areas	33	Segregate cooling water
	34	Lagoon for boiler blowdown and backwash waters

wire, etc. The stock is then usually screened at about 1% to 2% consistency, after which it is ready for cleaning. This is accomplished by passing the stock at about 0.5% consistency through centri-cleaners and fine screens. Generally, countercurrent washing is employed on washers of various types. Some mills employ flotation for separating the fiber from the undesirable materials and others use various kinds of deckering or thickening equipment. Fiber leaves the washers and is delivered to a stock chest at 6% to 15%.

Deinking practices in a tissue or molded pulp mill do not vary appreciably from the above. However, cooking temperatures for papers high in groundwood content are generally lower -- 38° to 71°C with a pH below 10. In addition, sodium peroxide is frequently added to the cooking liquor since its bleaching action tends to prevent browning of the pulp. Alkali and other detergents and dispersing agents are used in the deinking formula to remove rosin sizing from the paper and to saponify the ink vehicle and release the pigment in the ink. These substances which are sometimes used in combination with alkali include:

- Sulfonated Oils
- Bentonite
- Sodium Silicate
- Silicate Penthydrate
- Sodium Carbonate
- Sodium Hydroxide
- Hydrogen Peroxide
- Zinc Hydrosulfite

No data are available to quantify the amounts of these materials used.

Newsprint is deinked by a proprietary process employing a special detergent (15). The pulp produced is suitable for conversion on high-speed newsprint paper machines with the addition of little, if any, long fiber stock and may not require bleaching.

Deinked fibers consisting primarily of bleached chemical pulp are bleached in one stage with chlorine or calcium or sodium hypochlorite. From 2% to 5% of available chlorine is commonly used. Consistencies of the bleached pulp range from 3% to as high as 12%; tower type bleaching is used for the higher consistencies. When pulps containing considerable lignin are bleached after deinking, the three-stage process illustrated in Figure 22 is used. This process is commonly applied to kraft and sulfite pulps. In this process, 3% of chlorine is applied to a dilute slurry of pulp at ambient temperature. The pulp is then thickened and treated with caustic soda at 38°C which is followed by washing and treatment with hypochlorite. A variety of equipment and variations of this process are in use. Pulps high in groundwood are bleached by the methods employed for groundwood alone and variations thereof employing caustic soda, peroxides, and hydrosulfites.

The major sources of effluent from the deink process are the washers and centricleaners; the remaining streams consist mainly of miscellaneous white water overflows, floor drainage, wash up and cooling towers. Clarified white water from paper making operation may supply a considerable amount of the water used for washing and cooling. The entire wastewater flow from a single stage bleaching operation can also be used in a deink mill for dilution and preliminary wash water.

Major polluting characteristics of deinking effluents are BOD and TSS, which are both settleable and dispersed (5). The range of BOD and TSS loads from deinking operations are presented in Table 40. Organic materials present in these waste streams include adhesives, products of hydrolysis and fibers lost in the process. Inorganic constituents occur from mineral fillers, ink pigments, and other material separated from the fiber in waste water, as well as chemicals used in the process. Included in the latter are dissolved electrolytes (mostly sodium salts) and detergents, which add to the total solids and foaming characteristics of receiving waters. In Table 41, priority and nonconventional pollutants analyzed in deinking process effluent streams are presented for mills producing fine papers, tissue papers, and newsprint. Many of these mills use biological treatment systems and publicly operated treatment works (POTW) to reduce the concentrations of pollutant chemicals in the final effluent streams. Appendix C presents a further discussion on specific types of final effluent treatment systems used in this regard.

In Table 42 the results of a long term study to measure specific toxic and nonconventional pollutants in a deink tissue mill are presented. The sampling from which these data were derived was intended to evaluate the treatability of the chemically assisted primary clarification system for the pollutants of interest and estimate the levels entering the secondary treatment system.

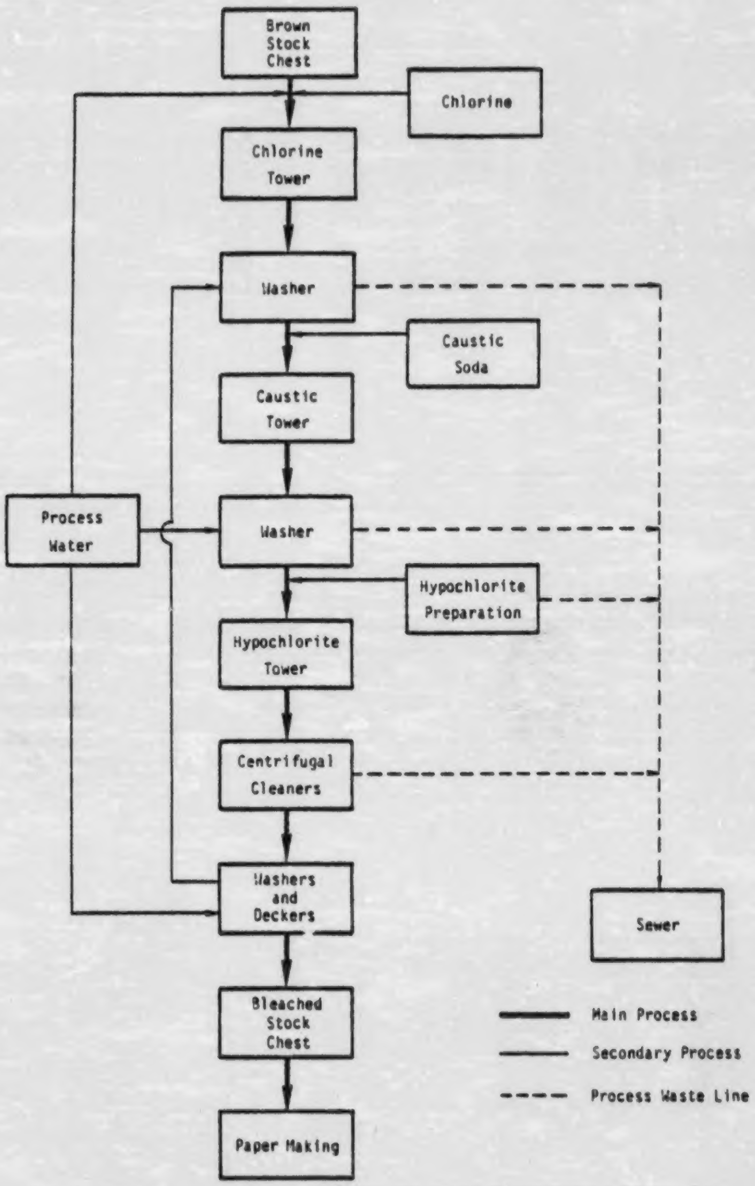

Figure 22 Three-Stage Deinked Pulp Bleach Plant Process Flow Diagram

Table 40 EFFLUENT CHARACTERISTICS OF DEINK PULP PROCESSING

	pH	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Range	--	1.5-141	1.5-374	8.3-156
Mean	9.3	51	171	90

Solid wastes accrue because deinking involves the use of waste paper. Therefore, waste such as those described for waste paperboard processing will be generated to a similar extent. Solid waste quantities should be smaller, however, since papers used are generally of much higher quality. Some solid wastes also accrue from the filler and other solids separated from the recycled paper.

Table 41 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN DEINK PROCESSING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/l) Untreated (Raw) Range	Concentration (μg/l) Untreated (Raw) Average	Concentration (μg/l) Treated (Final) Range	Concentration (μg/l) Treated (Final) Average	Percent Reduction	Treatment Type
Benzene	(FP)	0-7	2	0-3	1	50	Biological
	(TP)	0-6	3	2-3	3	0	Partial[a]
	(TP)	0	0	0-4	1	0	Biological
Chlorobenzene	(TP)	37-47	43	0	0	100	Partial[a]
	(TP)	0	0	0	0	--	Biological
1,2-Dichloroethane	(TP)	0-5	3	0	0	100	Partial[a]
	(TP)	0	0	0	0	--	Biological
1,1,1-Trichloroethane	(FP)	6-53	22	0	0	100	Biological
2,4,6-Trichlorophenol	(FP)	0-16	7	0-21	7	0	Biological
	(TP)	29-65	48	39-43	41	14.6	Partial[a]
	(TP)	0	0	0	0	--	Biological
Chloroform	(FP)	670-9700	4190	95-240	145	96.5	Biological
	(TP)	1000-1800	1367	48-61	55	96	Partial[a]
	(TP)	12-46	25	2-10	5	80	Biological
	(N)	1	1	*	--	--	POTW
2-Chlorophenol	(FP)	0-2	1	0	0	100	Biological
2,4-Dichlorophenol	(FP)	0-5	2	0-3	1	50	Biolgoical
	(TP)	1-5	4	0-2	1	75	Partial[a]
	(TP)	0	0	0	0	--	Biological
Ethylbenzene	(N)	0-4	2	*	--	--	POTW
	(TP)	27-45	33	0	0	100	Partial[a]
	(TP)	0	0	0	0	--	Biological
Methylene Chloride	(TP)	11-14	12	1-3	2	83.3	Partial[a]
	(TP)	0	0	0	0	--	Biological
	(N)	0-3	1	*	--	--	POTW
Naphthalene	(FP)	67-190	142	0	0	100	Biological
	(TP)	0-78	48	0	0	100	Partial[a]
	(TP)	0	0	0	0	--	Biological
Pentachlorophenol	(FP)	9-24	15	4-20	12	20	Biological
	(TP)	10-61	38	27-38	34	10.5	Partial[a]
	(TP)	0	0	0	0	--	Biological
Phenol	(FP)	8-41	22	0	0	100	Biological
	(TP)	76-150	119	0	0	100	Partial[a]
	(TP)	0	0	0	0	--	Partial[a]
	(N)	0-4	1	*	--	--	POTW
Bis(2-Ethylhexyl) Phthalate	(FP)	0-10	4	0-4	3	25	Biological
	(TP)	4-26	13	3-5	4	69.2	Partial[a]
	(TP)	0-20	8	0-2	1	87.5	Biological
	(N)	8-20	13	*	--	--	POTW
Butyl Benzyl Phthalate	(N)	3-8	5	*	--	--	POTW
Di-n-Butyl Phthalate	(FP)	3-9	5	0-12	6	0	Biological
	(TP)	0-10	3	0-12	5	0	Partial[a]
	(TP)	0	0	0	0	--	Biological
	(N)	0-2	1	*	--	--	POTW
Diethyl Phthalate	(FP)	0-10	3	0-6	2	33.3	Biological
	(N)	0-4	1	*	--	--	POTW
Tetrachloroethylene	(FP)	22-180	95	0	0	100	Biological

(Continued)

Table 41 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN DEINK PROCESSING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction	Treatment Type
		Untreated (Raw)		Treated (Final)			
		Range	Average	Range	Average		
Toluene	(FP)	11-150	58	0	0	100	Biological
	(TP)	10-20	15	0-1	1	93.3	Partial[a]
	(TP)	1-4	3	0	0	100	Biological
	(N)	5-20	14	*	--	--	POTW
Trichloroethylene	(FP)	130-850	493	3-11	7	98.6	Biological
	(TP)	8-13	11	0	0	100	Partial[a]
	(TP)	0	0	0	0	--	Biological
PCB-1242	(FP)	0-9.9	3	0	0	100	Biological
PCB-1254	(TP)	0-4	1	0	0	100	Biological
	(TP)	0	0	0	0	--	Partial[a]
PCB-1260	(TP)	0-3	1	0	0	100	Partial[a]
	(TP)	0-<1	<1	0	0	100	Biological
Chromium	(FP)	29-49	42	2-9	5	88.1	Biological
	(TP)	12-18	15	6-20	12	20	Partial[a]
	(TP)	4-13	8	<1-3	2	75	Biological
	(N)	<5-54	29	*	--	--	POTW
Copper	(FP)	42-80	61	<2-11	6	90.2	Biological
	(TP)	22-37	29	12-40	22	24.1	Partial[a]
	(TP)	8-21	13	<1	<1	>92.3	Biological
	(N)	57-80	76	*	--	--	POTW
Cyanide	(FP)	32-162	108	40-96	72	33.3	Biological
	(TP)	72-110	88	170-200	185	0	Primary
	(TP)	<10	<10	<10	<10	--	Biological
	(N)	720-2600	1560	*	--	--	POTW
Lead	(FP)	64-320	149	24-30	28	81.2	Biological
	(TP)	<2-44	22	<1-22	10	54.5	Partial[a]
	(TP)	<1-30	12	<1-3	2	83.3	Biological
	(N)	28-260	163	*	--	--	POTW
Mercury	(FP)	<0.5	<0.5	<0.5	<0.5	--	Biological
	(TP)	<0.5	<0.5	<0.5	<0.5	--	Partial[a]
	(TP)	<0.5	<0.5	<0.5	<0.5	--	Biological
	(N)	<0.5-2.4	1.2	*	--	--	POTW
Nickel	(FP)	5-20	15	<2-7	4	73.3	Biological
	(TP)	4-9	6	<2-6	3	50	Partial[a]
	(TP)	<1-4	2	<1-4	2	0	Biological
	(N)	5-30	15	*	--	--	POTW
Zinc	(FP)	97-352	206	30-38	33	84	Biological
	(TP)	170-260	200	51-82	71	64.5	Partial[a]
	(TP)	30-46	40	5-36	19	52.5	Biological
	(N)	300-375	335	*	--	--	POTW
Abietic Acid	(FP)	700-990	837	0-31	12	98.6	Biological
	(N)	2300-4100	3467	*	--	--	POTW
	(TP)	370-680	557	50-140	97	82.6	Partial[a]
	(TP)	330-740	513	40-90	72	86	Biological
Dehydroabietic Acid	(FP)	1400-2900	2267	42-62	49	97.8	Biological
	(TP)	2600-4800	3700	*	--	--	POTW
	(TP)	2200-4700	3267	130-630	343	89.5	Partial[a]
	(N)	1400-2400	1833	180-300	253	86.2	Biological

(Continued)

Table 41 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN DEINK PROCESSING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction	Treatment Type
		Untreated	(Raw)	Treated	(Final)		
		Range	Average	Range	Average		
Isopimaric Acid	(FP)	420-900	587	1-9	5	99.1	Biological
	(N)	240-690	510	*	--	--	POTW
	(TP)	110-180	150	14-24	18	88	Partial[a]
	(TP)	120-270	193	1-20	13	93.3	Biological
Pimaric Acid	(FP)	92-160	127	0	0	100	Biological
	(N)	220-310	257	*	--	--	POTW
	(TP)	31-52	39	0	0	100	Partial[a]
	(TP)	36-160	80	0	0	100	Biological
Oleic Acid	(FP)	500-1200	967	30-75	49	94.9	Biological
	(N)	1300-1500	1367	*	--	--	POTW
	(TP)	190-710	400	470-750	590	0	Partial[a]
	(TP)	310-560	410	220-280	243	40.7	Biological
Linoleic Acid	(FP)	260-650	470	0	0	100	Biological
	(N)	160-1200	750	*	--	--	POTW
	(TP)	38-86	55	0	0	100	Partial[a]
	(TP)	74-320	178	0	0	100	Biological
Linolenic Acid	(FP)	85-330	212	79-120	99	53.3	Biological
	(N)	<100-<200	<167	*	--	--	POTW
Chlorodehydroabietic Acid	(FP)	330-730	467	0	0	100	Biological
	(TP)	18-28	24	0-26	14	41.7	Partial[a]
	(TP)	0	0	0	0	--	Biological
Dichlorodehydroabietic Acid	(FP)	0-12	6	0	0	100	Biological
Trichloroguaiacol	(FP)	0-28	14	10-17	14	0	Biological
Tetrachloroguaiacol	(FP)	4-16	8	6-13	9	0	Biological
Xylenes	(FP)	0-20	7	0	0	100	Biological
	(N)	5-110	46	*	--	--	POTW
	(TP)	0-9	5	0	0	100	Biological
	(TP)	0	0	0	0	0	Partial[a]
Color	(FP)	48-140[b]	103	31-90[b]	68	34	Biological
	(N)	160-420[b]	320	*	--	--	POTW
	(TP)	210-220[b]	217	100-190[b]	153	29.5	Partial[a]
	(TP)	<5[b]	<5[b]	<5[b]	<5	--	Biological
COD	(FP)	700-2850[c]	1600	50-260[c]	170	89.4	Biological
	(N)	1980-4720[c]	3733	*	--	--	POTW
	(TP)	1700-2400[c]	2063	360-500[c]	430	79.2	Partial[a]
	(TP)	370-512[c]	435	77-87[c]	82	81.1	Biological

Subcategory Key:
FP - Fine Papers
N - Newsprint
TP - Tissue Papers

[a] Partial final effluent
[b] Color concentrations given in platinum cobalt units
[c] COD concentrations given in mg/l
*No sample taken

Table 42A LONG-TERM SAMPLING FOR TOXIC POLLUTANTS AT A DEINK-TISSUE PAPER MILL (1)

Chemical	Concentration Range (μg/l)			Average Concentration (μg/l)		
	Raw Waste	Secondary Influent	Final Effluent	Raw Waste	Secondary Influent	Final Effluent
2,4,6-Trichlorophenol	0-16	0-15	0-22	8.8	8.4	3.7
Chloroform	19-600	60-800	10-61	273	262	32
2,4-Dichlorophenol	0-6	0-2	0-8	1.8	0.4	0.4
Pentachlorophenol	0-13	0-12	0-23	4.8	3.8	2.5
PCB-1242	2-77	0.6-9.6	0.2-1.9	21.3	3.8	0.8

Table 42B LONG-TERM SAMPLING FOR NONCONVENTIONAL POLLUTANTS AT A DEINK-TISSUE PAPER MILL (1)

Chemical	Concentration Range (μg/l)			Average Concentration (μg/l)		
	Raw Waste	Secondary Influent	Final Effluent	Raw Waste	Secondary Influent	Final Effluent
Abietic Acid	55-156	34	0	110	34	0
Dehydroabietic Acid	180-405	275	0-16	291	275	5
Isopimaric Acid	19-57	81	0-5	36	81	0.5
Pimaric Acid	0-13	0	0-11	4.3	0	1.4
Oleic Acid	0-322	0	0-8	107	0	0.7
Linoleic Acid	120-286	49	0	187	49	0
Linolenic Acid	0-90	0	0-10	30	0	0.9
Epoxystearic Acid	11-44	0	0-6	26	0	0.5
Dichlorostearic Acid	0-25	0	0-64	8.3	0	13
Monochlorodehydroabietic Acid	0-14	0	0	4.7	0	0
Dichlorodehydroabietic Acid		(Not Detected)			(Not Detected)	
3,4,5-Trichloroguaiacol		(Not Detected)			(Not Detected)	
Tetrachloroguaiacol		(Not Detected)			(Not Detected)	
Palustric Acid	20-59	17	0	39	17	0
Levopimaric Acid	0-37	0	0	12	0	0
4,5,6-Trichloroguaiacol		(Not Detected)			(Not Detected)	
Neoabietic Acid		(Not Detected)			(Not Detected)	
4,5-Dichloroguaiacol		(Not Detected)			(Not Detected)	
Sandaracopimaric Acid	0-44	0	0	15	0	0
2,4,5-Trichlorophenol	0-11	0-10	0-8.4	0.5	0.5	0.3
Dimethyl Sulfide		(Not Detected)			(Not Detected)	
Dimethyl Disulfide		(Not Detected)			(Not Detected)	

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SECTION 5

PAPERMAKING OPERATIONS ANALYSIS

In this section, the operating characteristics of the variety of manufacturing processes, operations, chemicals and equipment used in each study area for the manufacture of paper are described. For the analysis of each study area, a process description, flow diagram, illustrations and appropriate tables present general information to provide a context for the evaluation of information presented in other parts of this report.

The environmental release of conventional, nonconventional, toxic and priority chemical pollutants occurring in papermaking is also discussed. For this discussion pertinent data contained in the literature (1,2,3,4,5) is presented in the same manner as is provided in Section 4.

Although papermaking operations are often integrated with pulping processes, the discussion of papermaking in this section is presented in the context of nonintegrated paper and paperboard making. For this discussion stock preparation, papermaking and finishing operations will be described in general terms. For specific aspects of these operations which have been shown to contribute to occupational exposure problems, a more detailed description of pertinent aspects of papermaking and finishing operations, as well as other industry operations, is presented in Section 6.

PAPER AND PAPERBOARD MAKING (STUDY AREA 9)

Two basic types of papermaking machines are used to form paper, paperboard, or building board from pulp-fourdrinier and cylinder machines. Twin-wire paper machines were developed in the 1960's, and operate by principles similar to those of fourdrinier machines. Another popular machine is the Rotoformer which is essentially a fourdrinier machine in cyclinder form. Most paper and paperboard products are formed on fourdrinier, twin-wire, and similar machines. Multi-ply paperboard or building board products are usually formed on cylinder machines. A generalized process flow diagram for non-integrated paper and paperboard making is presented in Figure 23.

In Figure 23, which illustrates papermaking from stock preparation through the finishing operations, various process control measures are labeled. These control measures are presented in Table 43 and are discussed further in Appendix B.

After pulping and bleaching, the resulting stock is subjected to additional operations to prepare the material for use on the papermaking machine. These operations include beating and refining, application of additives, and blending and proportioning.

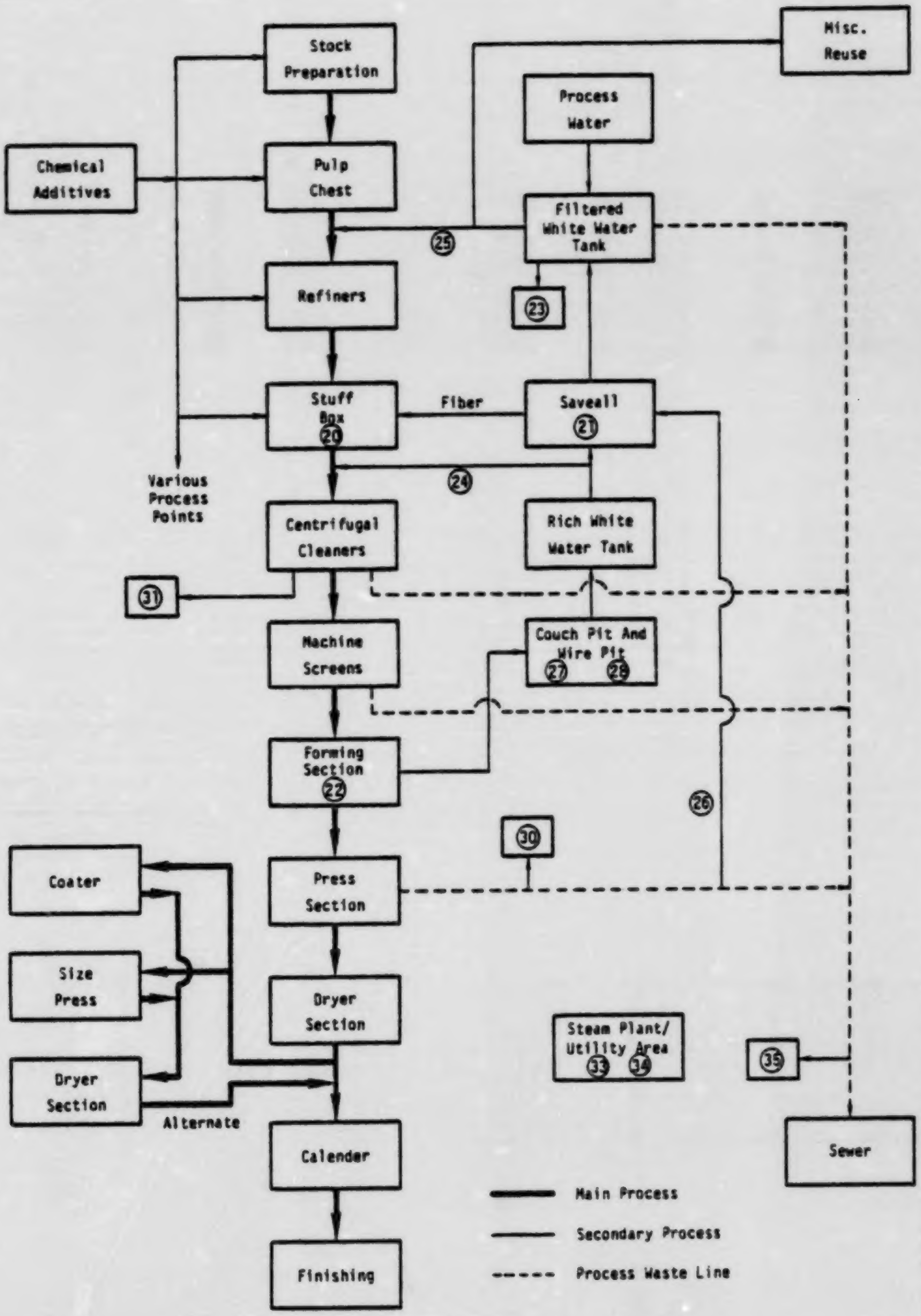


Figure 23 Paper Manufacturing Process Flow Diagram

Table 43 PAPER AND PAPERBOARD MAKING PROCESS CONTROL MEASURES

Process Component		Control Technology Description	Subcategories					
			Fine Papers	Tissue Papers	Tissue from Wastepaper	Light Weight	Filter and Nonwoven	Paperboard
Paper Machine; Color Plant	20	Spill collection	●	●		●	●	
Saveall	21	Improve saveall				●	●	
Fourdrinier	22	High pressure showers for wire and felt cleaning	●	●		●	●	
White Water System	23	White water use for vacuum pump sealing	●			●	●	●
White Water System	24	Paper machine white water showers for wire cleaning				●	●	●
White Water System	25	White water storage for upsets and pulper dilution				●	●	
Press Section	26	Recycle press water	●	●	●	●		●
Machine Pit	27	Reuse of vacuum pump water	●		●	●		●
Couch Pit	28	Broke storage				●	●	
Water Discharge Points	30	Segregate cooling water	●	●		●		
Cleaners	31	Cleaner rejects to landfill			●			
Steam Plant Utility Area	33	Segregate cooling water	●	●			●	●
Steam Plant Utility Area	34	Lagoon for boiler blowdown and backwash waters	●	●		●	●	
Effluent	35	Recycle of effluent			●	●	●	●

Pulp may be delivered from the pulp mill in an aqueous slush or slurry form, as wet or dry sheets (laps), as dry bales, shredded material, rags, straw or other fibers, as trimmings and other discarded material from the papermaking machine (broke), or as other forms of waste paper. Pulp stock is then reconstituted into a slurry form and blended with other components before use in papermaking. All pulps are subjected to mechanical action to separate and further prepare the fibers before being formed into a sheet. This is accomplished, to some extent, by the mechanical and chemical pulping processes described earlier. Two further processes by which pulp stock is prepared mechanically are beating and refining.

Beating (illustrated in Figure 24) is the oldest method of stock preparation and involves mixing pulp and various additives in a water suspension in an apparatus which crushes and abrades the fibers. Beating causes cellulose fibers to swell and increase in surface area by exposing smaller fibrillar elements due to the macerating effects of the beater. In this process the affinity of fibers for water is enhanced, as is fiber flexibility. Beating also increases the ability of fibers to bond together when dried, and increases homogeneity of the stock and the porosity and density of the resulting paper sheet.

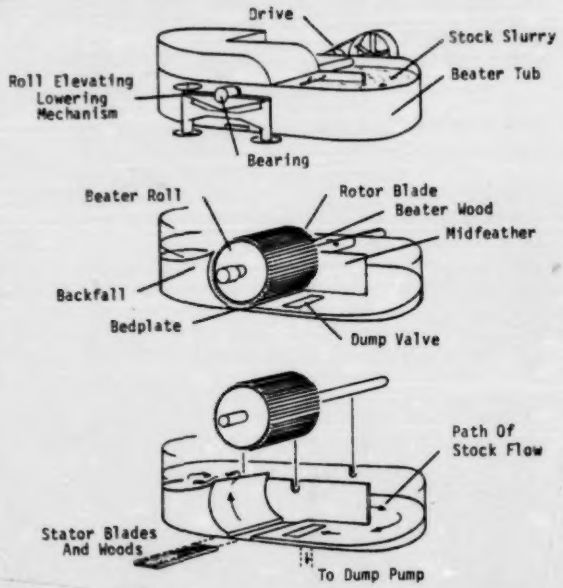


Figure 24 Beater (Simplified Representation)

Refining is a term often used synonymously with beating. The prototype refiner was the Jordan refiner, developed over 100 years ago. The Jordan refiner as shown in Figure 25, is used primarily to control fiber length in the last stage of refining. In many mills where continuous refining of pulp is routinely used (based refining), as opposed to the use of batch refining, a conical refiner (Claflin refiner), similar in construction to the Jordan, is used for initial fiber treatment. Although various types of refiners are used in paper mills, most operate on the principle of fiber abrading, crushing, and separation.

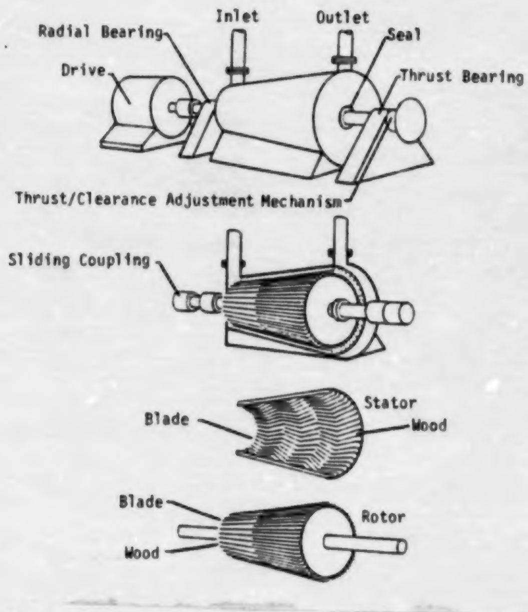


Figure 25 Jordan Refiner (Simplified Representation)

Hundreds of individual chemical agents are used in papermaking to further prepare fibers for the papermaking machine, to impart various characteristics to paper products, and to facilitate papermaking operations by controlling residue formation and microorganisms. Many of these agents are added to beaters or refiners. Others may be added to the wet end of the papermaking machine, the press section, during drying, or at the calender stacks. Various machine operating aids, such as pitch control agents and slimicides, are added to the papermaking process at the point where they are needed. One or more agents from various classes of additives may be added to pulp stock before papermaking operations are complete or may be used for control purposes. These major classes of additives, which are presented in Table 44, are discussed below.

All papers, with the exception of blotters or absorbent papers, must have a filler added to them to occupy the space between fibers. Fillers may be finely ground, naturally occurring materials such as talc or clay, or manufactured chemical agents such as precipitated calcium carbonate or titanium dioxide (which is also used as a pigment). Fillers may comprise 2% to 40% of the final weight of the paper sheet. Kaolin (a hydrate, aluminum silicate) is both a filler and a coating pigment.

Table 44 PAPERMAKING ADDITIVES

SIZING AGENTS

Sulfuric Acid
Aluminum Sulfate (Alum)
Casein
Rosin (0.5-20 kg/kkg)
Sodium Aluminate
Sodium Silicate
Styrene-Butadiene
Acrylamide
Steric Anhydride
Alkenyl Succinic Anhydride
Alkyl Ketene Dimer
Asphalt
Animal Glue
Natural Gum
Carnauba Wax
Candelilla Wax
Hydroxyethylcellulose
Carboxymethylcellulose
Starch
Hydroxyethyl Starch
Polyurethane
Styrene-Maleic Anhydride Copolymer
Polyvinyl Alcohol
Ammonium Stearate

WET-STRENGTH AND DRY-STRENGTH AGENTS

Ethylene-Vinyl Acetate Copolymer
Polyethylene
Starch
Styrene-Butadiene
Epichlorohydrin-Based Resin
Melamine Resin
Urea-Formaldehyde Resin
Polyacrylamide
Polyamide-Epichlorohydrin Resin
Polyvinyl Alcohol
Polyvinyl Acetate
Carob-Seed Gum
Guar Gum
Emulsified Latex
Cationic Dialdehyde Starch
Polyethyleneimine
Aminopolyamides
Sodium Carboxymethylcellulose
Tamarind Gum
Formaldehyde
Trimethylolmelamine
Poly(Methyldiallylamine)
Polyacrylamide-Glyoxal Resin
Polyacrolein
Chitosan
Polyurethane
Styrene-Maleic Anhydride Copolymer

ADHESIVES

Sodium Silicate
Ethylcellulose
Polybutylene
Latex
Acrylamide
Polyvinyl Alcohol
Polyvinyl Acetate
Polyethyleneimine
Acrylic Resin
Animal Glue
Natural Gum
Gelatin
Starch
Asphalt
Wax
Soy Protein
Casein
Sodium Borate
Ammonia

DYES AND PIGMENTS

Acid Blue 1, 9
Acid Green 3, 5
Acid Orange 10
Acid Red 87, 91
Basic Red 1
Basic Violet 10
Direct Blue 2, 6, 14, 53
Direct Brown 1, 2, 6, 31, 95, 154
Direct Black 4, 38
Direct Green 1, 6, 8
Direct Orange 1, 8
Direct Red 1, 13, 28, 37
Direct Violet 1
Pigment Blue 27, 29
Food Red 9
Solvent Yellow 34
Fluorescent Brightening Agent 30
Carbon Black
Silicic Acid
Potassium Titanate
Aluminum Hydroxide
Sodium Aluminosilicate
Iron Blue
Phthalocyanide Blue
Anthraquinone
Stilbene
Potassium Dichromate
Anisidines
Diphenylmethane
Iron Oxide
Lead
Lead Molybdate
Potassium Chromates
Benzidine
o-Tolidine
Cobaltic Oxide
Triphenylmethane Dyes

Table 44 (Continued) PAPERMAKING ADDITIVES

BINDERS

- Casein
- Styrene-Butadiene
- Polyvinyl Alcohol
- Polyvinyl Acetate
- Polyvinyl Chloride
- Acrylic Resin
- Animal Glue
- Starch
- Carob-Seed Gum
- Guar Gum
- Soy Protein

PIGMENT FILLERS/COATINGS

- Aluminum Oxide
- Aluminum Silicate (14.5 kg/kkg)
- Barium Sulfate
- Styrene-Butadiene Copolymer
- Calcium Carbonate
- Calcium Sulfate
- Calcium Sulfoaluminate
- Ethylene-Vinyl Acetate Copolymer
- Ethylene Glycol Acetate Copolymer
- Magnesium Silicate
- Muscovite Mica
- Paraffin Wax
- Polyphosphates
- Polyvinylidene Chloride
- Talc
- Titanium Dioxide
- Zinc Oxide
- Zinc Sulfide
- Potassium Titanate
- Aluminum Hydroxide
- Sodium Aluminosilicate
- Calcium Silicate
- Polystryene Latex
- Urea-Formaldehyde Resin
- Chrysotile Asbestos
- Magnesium Aluminum Silicate (Hydrated)
- Kaolin
- Nitrocellulose
- Polybutylene
- Silica
- Carnauba Wax
- Phosphoric Acid
- Portland Cement

HUMECTANTS

- Glycerol
- Glyoxal
- Melamine-Aldehyde Resin
- Urea-Formaldehyde Resin
- Urea

COATINGS

- Ethylcellulose
- Calcium Resinate
- Ammonia
- Dibutyl Phthalate
- Linseed Alkyd
- Methylolacrylamide
- Polyethylene Glycols
- Sodium Abietate
- Polyvinyl Alcohol
- Low-Density Polyethylene
- Wax
- Carboxymethylcellulose
- Sodium Carbonate
- Sodium Hydroxide

WATER-RETENTION AIDS

- Carboxymethylcellulose
- Hydroxyethylcellulose
- Guar Gum
- Sodium Alginate

CREPING AIDS

- Animal Glue
- Aminopolyamides
- Aminopolyamide-Epichlorohydrin Resin
- Mineral Oil (Paraffin Oil)
- Silicone Oil

OIL-RESISTANT ADDITIVES

- Fluorochemical Chrome Complex
- Fluorochemical Copolymer
- Fluorochemical Phosphate
- Isopropyl Alcohol
- Ethylene Glycol Monobutyl Ether

FLAME RETARDANTS

- Sodium Phosphate, Dibasic
- Ammonium Phosphate, Dibasic
- Ammonium Sulfate
- Antimony Trioxide

ACID-BASE INDICATORS

- Bromothymol Blue
- Cresol Purple
- Cresol Red
- Phenolphthalein

MISCELLANEOUS ADDITIVES

- Chrysotile Asbestos (Paper Softener)
- Acetic Acid (Dye Solvents)
- Urea (Color Viscosity Reduction)
- Potassium Ferricyanide (Blueprint Paper Coating)
- Polyvinylpyridine (Antistat)
- 2,6-Bis(Dimethylaminomethyl)Cyclohexanone (Pigment, Adhesive Preservative)
- Sodium Chloride (Copy Paper Coating and Mordanting of Dyes)

Sizing refers to the materials which make paper more resistant to the penetration of liquids, and to the process of adding these materials to pulp or paper. Internal (beater, stock, or engine) sizing refers to the addition of material to water suspensions of pulp during beating or refining. External (surface, tub) sizing occurs when sizing material is applied to the formed and partially dried sheet of paper by a separate size press. Internal sizing involves addition of the sizing agent to the beater, followed by precipitation of the agent with alum (aluminum sulfate). A gelatinous film is formed on the pulp fiber, and a hardened surface results.

Coatings are applied to paper to improve the opacity or surface characteristics of the base stock (1). Barrier coatings include paraffin wax combined with certain dry-strength agents such as polyethylene or ethylene-vinyl acetate copolymer. Pigment coatings include natural or chemical fillers, as well as various adhesives. Adhesives may include various wet- and dry-strength additives alone or combined with other agents, such as casein combined with borax or ammonia, soy protein, polyvinyl alcohol and acetate, starch combined with melamine-formaldehyde or urea-formaldehyde mixtures, rubber latexes, and acrylic emulsions.

Coloring is added to most papers (2). The operation may occur during beating or refining, at the calender stacks, and after the paper has been formed (surface coloring). Dyes and pigments are used as coloring agents and are added after sizing agents, but before precipitation of sizing with alum. Basic dyes are hydrochloride, sulfate, or oxalate salts of certain color bases (3). Acetic acid may be used to improve solubility. Acid dyes are salts of colored acids such as sodium salts of dye sulfonic acids (monoazo compounds or anthraquinone derivatives). Since these dyes have little affinity for the fiber, sizing and alum are added.

Other chemicals added during the papermaking process include machine operating aids, such as retention aids, drainage aids, defoamers, biocides, and pitch control agents. These classes of additives are presented in Table 45.

Retention aids inhibit the loss of fiber fines (residuals) or pigment content during paper sheet formation. Drainage aids are materials that increase water removal as the paper sheet is formed. Defoaming agents may be added to control foam when fillers are mixed with pulp. Pitch control agents are materials that prevent formation of resinous material.

Refined pulp, into which these various additives are incorporated, is known as "furnish". A variety of batch or continuous-flow systems are used to blend pulp and additives to form the final furnish that is delivered to the papermaking machine.

Different pulps are separated, refined, and mixed together in appropriate proportions with metered amounts of alum, clay, sizing and other additives in a mixing chest. The blended stock is diluted with water to a consistency of 2.5% to 4.0%. The stock is then delivered to the stuff box, where the consistency is monitored and further regulated. In some cases, a final stage of refining is performed before delivery to the stuff box.

Table 45 MACHINE OPERATING AIDS

RETENTION AIDS

- Aluminum Sulfate (Alum)
- Dicyanodiamide
- Epichlorohydrin Copolymer
- Starch
- Polyacrylamide
- Chrysotile Asbestos
- Polyethyleneimine
- Polyamines
- Diethylenetriamine-Adipic Acid Polyamide
- Poly (Dimethyldiallylammonium Chloride)
- (2-Methacryloyloxyethyl)-Trimethylammonium Salt
- Diethylaminoethyl Methacrylate
- Dimethyldiallylammonia Chloride
- Acrylic Acid
- Polyvinylpyridine
- Poly(1,2-dimethyl-5-vinylpyridinium Methylsulfate)
- Calcium Chloride
- Aminoethyl Acrylate Copolymer

FOAM CONTROL AGENTS

- Sec-n-Octyl Alcohol
- Pine Oil
- Silicone
- Tributyl Citrate
- Tributyl Phosphate
- Tridecyl Alcohol
- Kerosene
- Sulfonated Oil
- Fatty Glyceride
- Fuel Oil
- Mineral Oil
- Cetyl Alcohol

PITCH CONTROL AGENTS

- Kerosene
- Aluminum Sulfate (Alum)
- Chrysotile Asbestos
- Bentonite
- Trisodium Phosphate
- Sodium Thiosulfate
- Sulfonated Naphthalene Formaldehyde
- Magnesium Silicate
- Silica
- Sodium Phosphate, Tribasic
- Talc

FORMATION AIDS

- Polyacrylamide
- Poly(ethylene oxide)
- Guar Gum
- Carob-Seed Gum
- Deacetylated Karaya Gum

DRAINAGE AIDS

- Starch
- Cationic Monogalactan
- Polyamines

LUBRICANTS

- Castor Oil
- Glycerol Monostearate
- Lithium Grease
- Diglycol Stearate
- Petrolatum
- Calcium Stearate
- Fatty Acid Esters
- Sulfonated Oil
- Wax

SUFACTANTS (EMULSIFIERS, DISPERSANTS)

- Sodium Polyacrylate
- Polyphosphates
- Trihydroxyethylamine Oleate
- Triethanolamine
- Sodium Xylene Sulfonate
- Sodium Sesquicarbonate
- Potassium Phosphate, Dibasic
- Lecithin
- Lignin Derivatives
- 2-Dimethylaminoethanol
- Cationic Monogalactan
- Cetyl Alcohol
- Sodium Hexametaphosphate

BIOCIDES AND SLIME CONTROL AGENTS

- Acrolein
- Alkyl(C_{12}-C_{16})dimethylbenzylammonium Chloride
- Bis(trichloromethyl) Sulfone
- 3,5-Dimethyl-1,3,5,2H-tetrahydrothiadiazine-2-thione
- Sodium Dimethyldithiocarbamate
- Sodium ortho-Phenylphenate
- Sodium Pentachlorophenate
- Sodium 2,4,5-trichlorophenate
- Sodium 2,4,6-trichlorophenate
- Phenyl Mercuric Acetate
- Bis-1,4-bromoacetoxy-2-butene
- 2-Bromo-4-hydroxyacetophenone
- 2-Bromo-2-nitropropane-1,3-diol
- Pentachlorophenol
- N,N-dimethyldithiocarbamate
- Ethylene-bis-dithiocarbamate
- Ethylenediamine
- Ethylene Glycol
- Isocyanates
- Isopropyl Alcohol
- 2-Benzothiazolethiol
- N-methyl Dithiccarbamate
- Methylene-bis-thiocyanate
- N-[a-(1-nitroethyl)benzyl]ethylenediamine
- Paraclox
- N-(1-phenyl-2-nitropropyl)piperazine
- 1,1,1-Trichloroethane

MISCELLANEOUS AIDS

- Aluminum Sulfate (pH Control)
- Sodium Dodecylbenzenesulfonate (Anionic Detergent)
- Sodium Myristylsulfate (Anionic Detergent)

From the stuff box, the furnish is diluted to a consistency of 0.1%-1.0% by recycled white water from the papermaking machine. The furnish is then passed through a series of centrifugal cleaners and screens to obtain a uniform fiber dispersion. The furnish is then passed through a deculator, which is a vacuum system for removal of air bubbles, and then to a fan pump and pressure screen for delivery to the forming section.

Although papermaking machine operations are automated, most can be modified by operator actions and require monitoring. The machine tender generally has responsibility for operations that lead to sheet formation. The backtender, with the assistance of the third, fourth, and fifth hands, usually is responsible for operations that control the properties of the formed sheet after it has been dried.

The fourdrinier machine, as shown in Figure 26, consists essentially of a long, endless plastic or bronze alloy wire screen belt (the fourdrinier wire) which moves the sheet of pulp through various presses and operations. The mesh count of the wire varies for each of the different paper products.

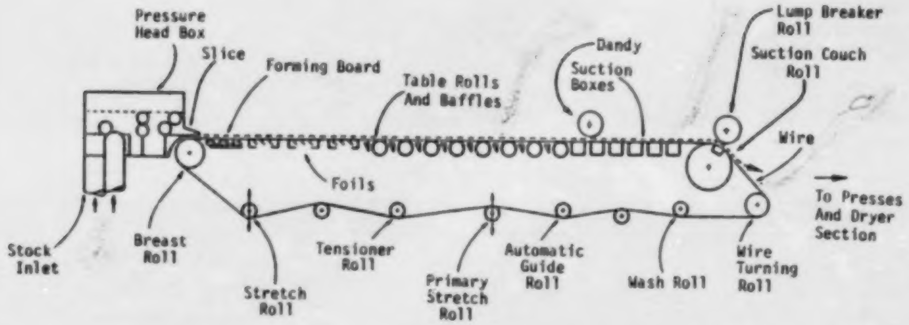


Figure 26 Fourdrinier Paper Machine

The previously prepared pulp stock or furnish, diluted to contain about 0.5% fiber (2), is first sent through screens to remove foreign matter. The stream or slurry is discharged into the paper machine head box where velocity of flow and turbulence is controlled, such that the slurry flows out through the slice (head box opening) and onto the moving fourdrinier wire at a constant rate.

The fourdrinier wire is mounted over breast and couch rolls and is supported in the middle by table rolls which are driven by the wire. As the flow of material progresses, the pulp fibers remain on the screen while water drains through. A side-to-side motion is used on some machines to orient the fibers and give strength to the sheet. While the pulp fibers are on the screen, water removal from the sheet is facilitated by the action of table rolls, foils, and suction boxes under the sheet. A dandy roll is usually located along the suction-box section. This roll consists of a light cylindrical frame covered with a wire screen with about half the mesh count of the fourdrinier wire. The paper sheet is smoothed as it passes under the dandy roll and produces the "dry line" on the sheet -- the line at which a glossy water surface disappears. Foam or air bubbles are also removed by the dandy roll. On some machines, decorative patterns are fixed to the dandy roll surface and are transferred to the paper sheet as watermarks.

After the paper leaves the fourdrinier wire at the couch roll, it is transferred to a felt blanket which carries the sheet through the wet press section, which contains a series of press rolls and felt blankets that remove more water. After this process, the sheet contains approximately 65% water. The felt blankets act both as conveyors and as porous receptors to aid in water removal. Press rolls may be made of granite, steel or cast iron covered with plain rubber or rubber that contains mineral fillers (3). Most of the felts are chemically treated to resist bacterial and mechanical deterioration. The fourdrinier and wet press sections are known as the "wet end" of the paper machine.

The paper from the press section is passed through a series of hollow, steam-heated iron or steel rolls, as shown in Figure 27, and dried to about 6% water content (3). Sizing may be sprayed onto the paper sheet during the drying operation, in which case the paper sheet must pass through a size press and a series of drying rolls. Up to a ton of water per minute is removed during the drying process (4).

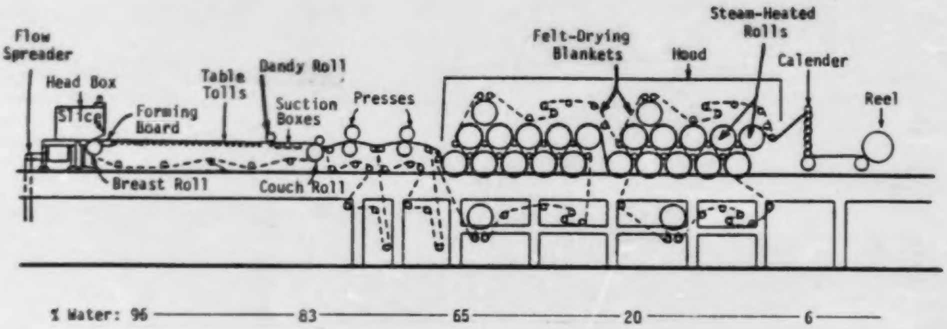
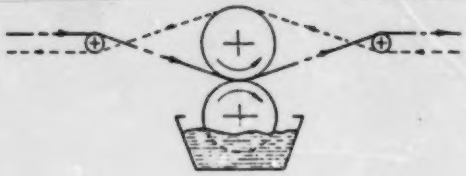


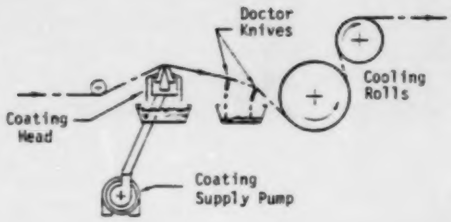
Figure 27 Pressing and Drying After the Fourdrinier Section

Multiple steam-heated drying rolls are used on most paper machines. The usual procedure, especially on paperboard machines, is to program the operation so that the speed of travel of the sheet through each successive drying section is reduced. Drying of the sheet also may be accomplished in other ways. The Yankee drier is a steam-heated cylinder which dries the sheet from one side. With this device, machine-glazed papers are produced that have a high finish on the surface as a result of contact with a highly polished dryer roll (5).

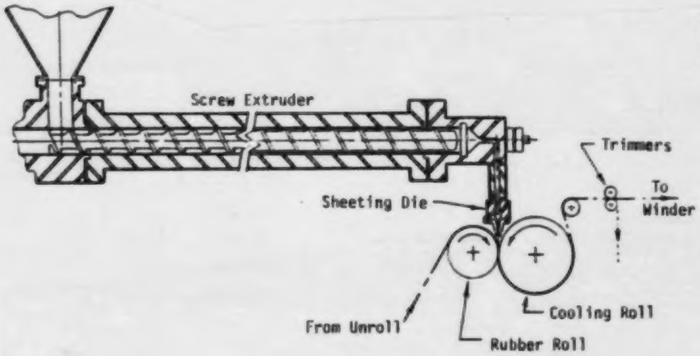
After drying, the sheet may pass through a coater (see Figure 28), a size press and an additional drying section before pressing through the calender rolls. Calendering is used to impart a surface finish to the paper by a combination of compression and friction.



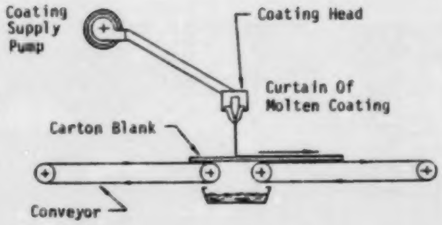
Basic Roll Coater



Hot Melt Coater



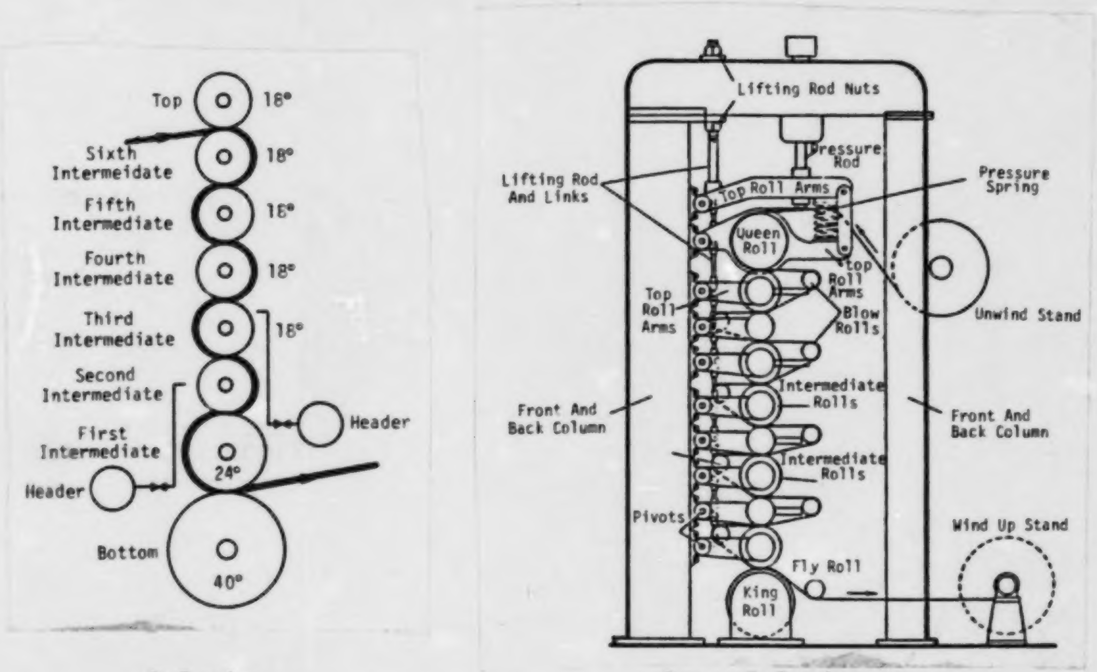
Extrusion Coater



Curtain Coater

Figure 28 Four Transfer Roll Coater Designs

In paperboard mills there are usually 2 and sometimes 3 sets of calender stacks. The calender stack immediately following the dryer section is known as the wet stack; the second set is the dry stack. In paperboard mills, water, starch solutions and coloring may be added to the sheet at the wet stack (6). A breaker stack is also used in paperboard mills to smooth lumps in the board and to control caliper of the sheet. Supercalenders are calender stacks in which chilled metal and fiber-filled rolls alternate. They are are used off the paper machine and have their own wind and unwind stands. They are used to impart a smoother finish to paper than that afforded by machine calenders. The number of rolls in a supercalender may vary from 3 to 9 for single-sided finishing, and from 4 to 20 for double-sided finishing (7). Diagrammatic representations of a calender and supercalender are provided in Figure 29.

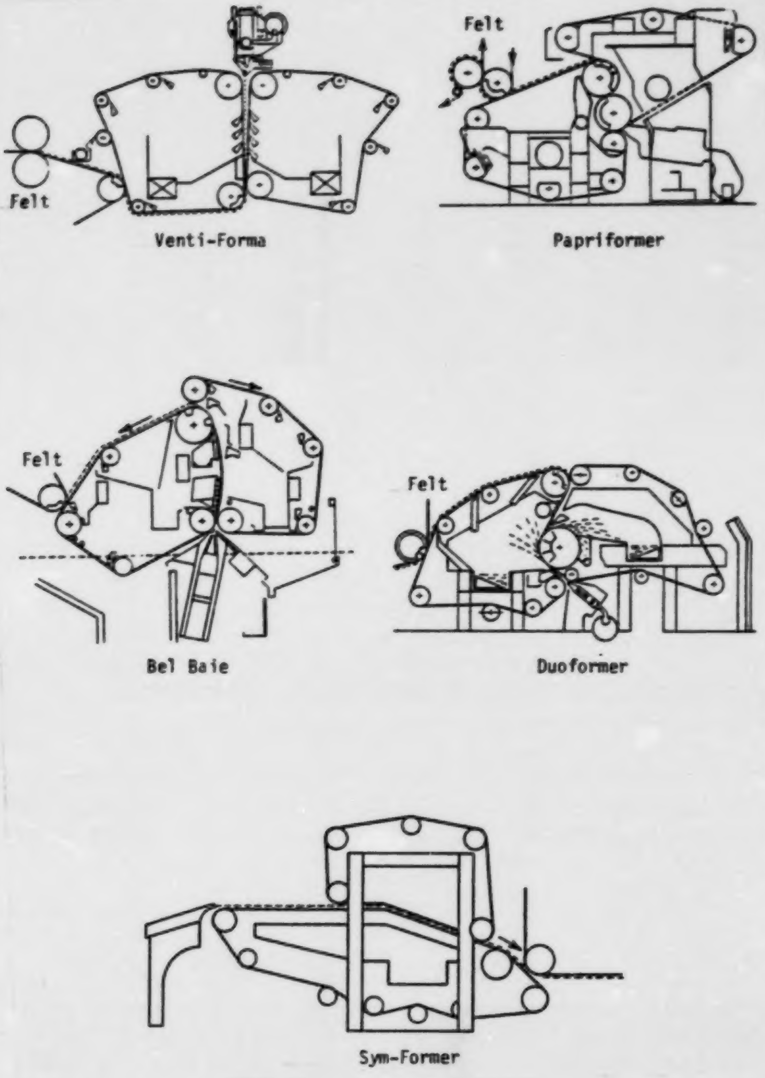


Calender

Super Calender

Figure 29 Paper Machine Calender and Supercalender

In the twin-wire machine, the paper sheet is produced between two endless-loop wire belts that are drained in both directions away from the sheet as it is formed. This is accomplished by the use of inverted as well as normally-placed suction boxes to increase drainage rate. This procedure contributes to greater sheet uniformity, eliminates the slightly different properties of each side of the paper normally seen in paper from single-wire machines, and allows the use of high speeds in a machine that occupies half the space of a fourdrinier machine (6). Five typical twin-wire formers are illustrated in Figure 30.



Venti-Forma

Papriformer

Bel Baie

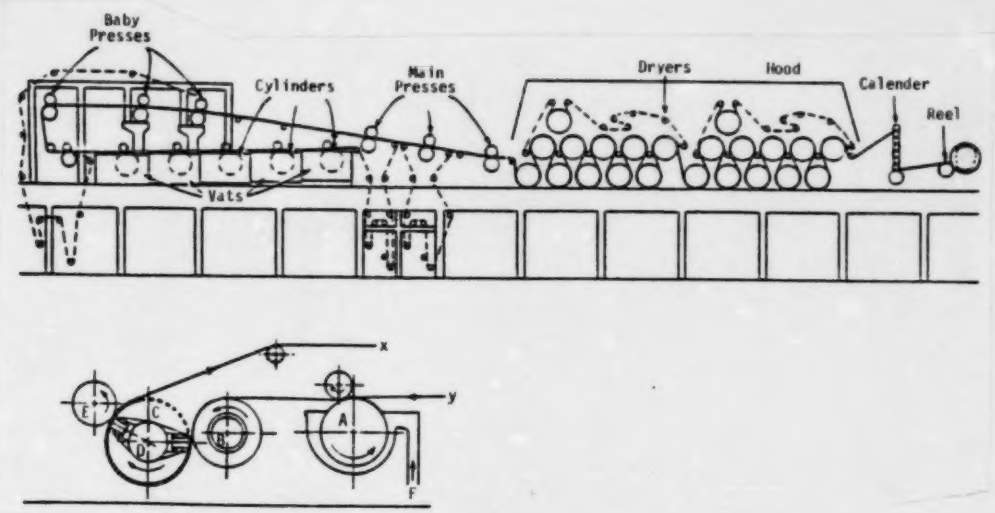
Duoformer

Sym-Former

Figure 30 Typical Twin-Wire Formers

Other machines, such as the Verti-Forma, use a vertical flow of stock which further decreases the floor space taken by the paper-forming and dewatering sections. Conventional pressing, drying, and calendering processes are used to finish the paper sheet.

Cylinder machines as illustrated in Figure 31, are usually used for the manufacture of corrugated containers, heavy construction paper, or multi-ply building board. They operate at much slower speeds than fourdrinier machines. Combination fourdrinier-cylinder machines are common in Europe, where they are used for production of card stock and high-grade boxboard (6).



(A) Last cylinder which takes up slurry (F) from vat; B: extractor; C: perforated cylinder containing D: stationary water extractor; E; baby press; x: paper on way to dryers; y: wet-paper sheet from previous cylinders

Figure 31 Cylinder Machine and Detail of Last Cylinder with Water Extractor

In a multicylinder paperboard-making machine, the sheet-forming section consists of separate vats, each with its own cylinder mold and smaller couch roll. The machine has from 4 to 7 vats into which similar or dissimilar dilute (3.5%-4.0%) paper stocks are discharged from a stock-entry system (2). Formation of a fibrous web occurs on the mesh covering of the cylinder mold when the stock suspension is forced through the wire mesh by differential pressure heads on opposite sides of the cylinder mold (6). The filtrate or white water is recycled and returned to the vats. The fibrous web on the cylinder mold is couched or pressed from the cylinder by means of a couch roll that transfers the paperboard web to a pick-up felt. The pick-up felt carries the material to other vats where new webs from each cylinder become attached to the previously couched webs. In this way, a multi-ply sheet, having a water content of 88%, is formed on the pick-up felt.

After leaving the last cylinder, additional water is removed from the sheet by suction press rolls. The sheet is carried on felt blankets to the primary and main press sections. Drying and calendering processes for fourdrinier and cylinder machines are essentially similar, except for drying procedures that use circulation of hot air for drying to a greater extent than pressing operations using heated drums.

Various accessory pieces of equipment along the path of paper travel facilitate the papermaking process. Whippers are rapidly-revolving felt cleaners which are operator controlled. These cleaners shake out the dirt and stock that have been loosened by felt showers positioned along the felt path. Showers also remove stock from the cylinder molds. Inverted suction boxes may be installed over the felt between vats, as well as in their normal position under dryers.

The rotoformer is a versatile device for forming a paper sheet that can support its own weight, and is used for manufacturing many varieties of paper and board. Figure 32 illustrates a basic roto former design. The device consists of a stainless-steel or bronze cylinder covered with wire mesh, containing multiple internal suction boxes. The cylinder does not rotate in a vat but is fed stock through a headbox and pond regulator. In a multiple cylinder arrangement, a pick-up felt couches the web from the top of the cylinder (6).

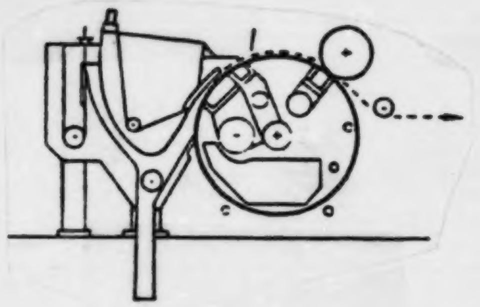


Figure 32 Rotoformer (Simplified Representation)

Various surface treatments, such as sizing, coating and coloring, can be applied to paper or board at several points in papermaking processes. Sizing may be applied at the dandy roll, suction boxes, wet presses, the size press or at the machine calenders (6). The size press consists of a pair of rolls similar to those of the wet-press section of the fourdrinier machine. The press is located in the dryer section and receives the paper sheet after it has been dried to between 4% and 12% moisture content (3). The sizing or pigment is sprayed on one or both sides of a sheet while the bottom roll revolves in a bath of sizing in a vertical size press. In a horizontal size press, the sizing is sprayed into the nip on both sides of the sheet as the paper travels down through two horizontal press rolls. Inclined size presses operate in a similar manner, and also minimize the tendency for shrinkage of the paper sheet. Tub sizing is an older process of off-machine surface sizing where still-wet paper is lead through a vat filled with sizing, and the excess is squeezed from the paper by a pair of press rolls. The resulting roll or wet pack may be stored for some time to distribute the sizing evenly and then dried in a special dryer, where the paper is hung in loops and hot air is circulated around them (6).

Finishing operations begin after the last operation on the papermaking machine and end at the point where the product leaves the mill (6). These operations include supercalendering, rewinding, and slitting, cutting and sheeting, trimming, packaging and shipping, as well as off-machine sizing operations discussed above.

Rewinding of the paper roll is performed either as part of the production process in the finishing room or to eliminate defects in the roll when it is removed from the papermaking machine. These include variations in density or other problems identified by the backtender that a rewinding operation may correct. The production rewinder is used to split the machine-width sheet into smaller widths so that rolls of paper of the correct size may be shipped to customers. Another major use is to provide uniform, tightly-wound paper rolls that can be used in high-speed printing presses with few tension problems (7).

A typical rewinder consists of the unwind, winding drums, slitters, and side frames. The rewinder is usually several inches wider than the paper machine and is operated at 3.0-3.5 times the speed of the paper machine. The unwind accepts the paper machine roll spool, and the paper is threaded between the rewinder drums, through the slitters, and around a paper core on which it is rewound. Many winders are equipped with a feature that allows the operator to move the original reel back and forth several inches in order to spread any caliper variations over a large area of the rewound roll. Hand wheels also allow up and down movement of the rewind shaft. Two major types of rewinders that are used are the two-drum rewinder, and the multiple individual rewinder (7).

Slitting is accomplished by the use of devices shown in Figure 33. The score slitter consists of a circular knife that rotates on the surface of a hardened-steel roll that is driven by the rewinder. The shear slitter is constructed of two circular knives that cut the paper as it contacts their sharp edges. Both types of slitters are adjustable, and allow cutting of paper rolls to specific widths (7).

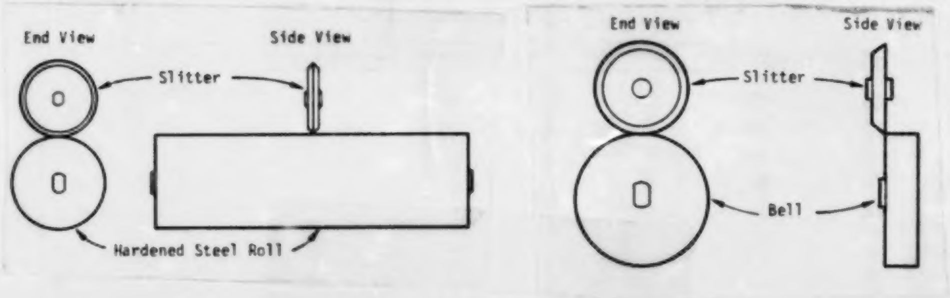
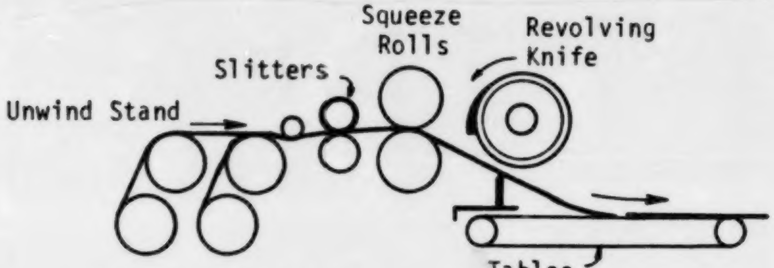
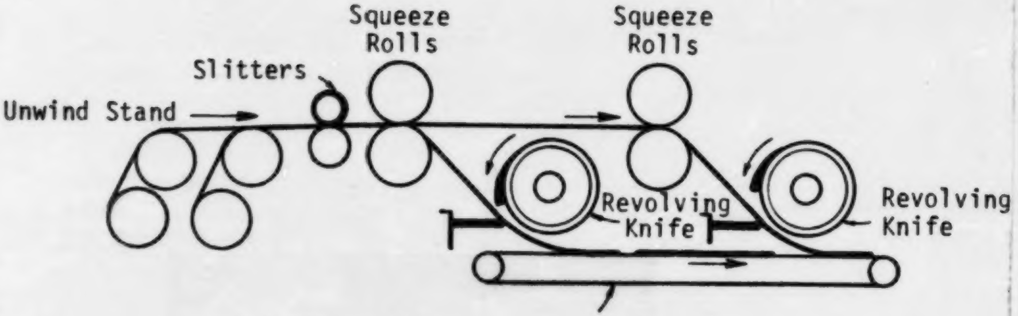


Figure 33 Slitters Used in Paper Finishing

Rolls of paper from the rewinder that are to be cut directly into sheets are mounted on reel stands. As the paper is unwound, it passes through a cutter having a revolving knife or knives that cut the sheet into specific lengths with each revolution. The length of the sheet is determined by the speed of the revolving knife. Two types of cutters are shown in Figure 34. Slitters are also used during cutting to further modify the width and trim of the paper in the duplex cutter (7). Another view of the details of the slitter/cutter (duplex cutter) design is shown in Figure 35.



Simplex Cutter



Duplex Cutter

Figure 34 Simple and Duplex Cutter Designs

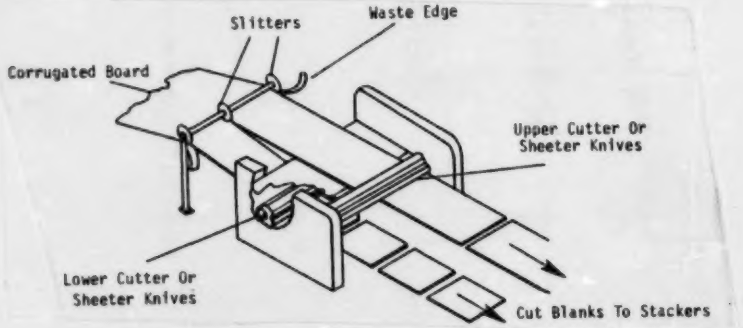

Slitters
Waste Edge
Corrugated Board
Upper Cutter Or Sheeter Knives
Lower Cutter Or Sheeter Knives
Cut Blanks To Stackers

Figure 35 Slitter-Cutter Design

The purpose of trimming is to trim the dimensions of a paper sheet to a final size, with a reported tolerance of +0.0156 inch. Several reams of paper from the cutter are placed on the bed of a trimmer press (guillotine cutter) by manual handling, or by automatic feed mechanisms. The trimmer press operator positions the stock against a back gauge and cuts are made on each side of the stock. A perforated, hollow 30-inch long metal "air-sword" is used to break the bond between sheets, facilitating movement of stocks of trimmed and untrimmed paper to and from the trimmer press bed (7). Various mechanical handling aids are used in trimming, and some of these are shown in Figure 36.

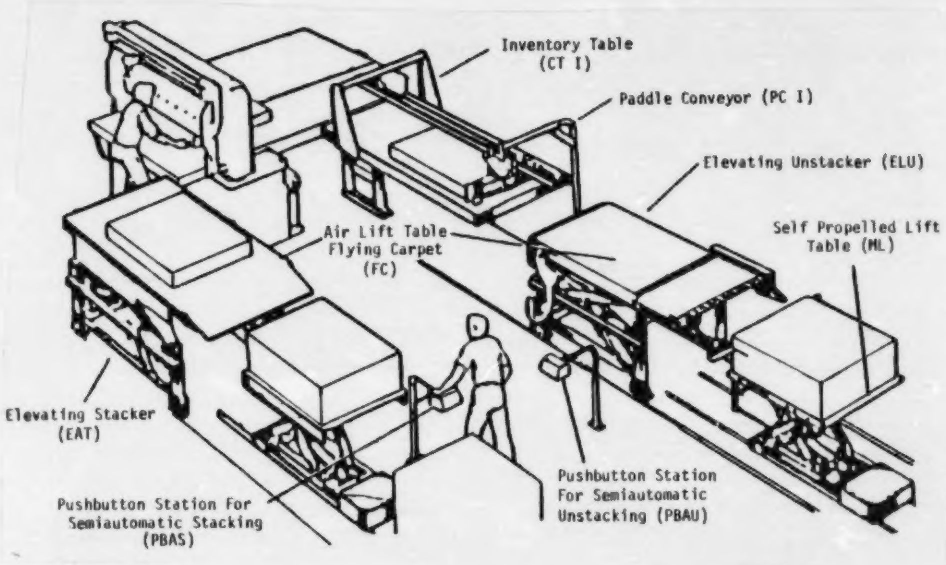

Inventory Table (CT I)
Paddle Conveyor (PC I)
Elevating Unstacker (ELU)
Self Propelled Lift Table (ML)
Air Lift Table Flying Carpet (FC)
Elevating Stacker (EAT)
Pushbutton Station For Semiautomatic Stacking (PBAS)
Pushbutton Station For Semiautomatic Unstacking (PBAU)

Figure 36 Handling Aids Used in Trimming

Roll-finishing operations begin with the removal of the roll from the paper machine winder or rewinder-slitter. In newsprint mills, roll finishing usually is fully automated, whereas semi-automatic systems for roll handling exist in other mills. One system that is used is operated in the following manner. Rolls from the winder travel by conveyor to a roll-sorting deck. One of the winder crew releases individual rolls to a belt conveyor, which discharges the roll to an automatic turntable on a raised platform (7). The turntable revolves 90° and discharges the roll down a ramp into a feeder. The next operations, which include roll wrapping, crimping, head gluing and heading and labeling, are performed by machines under operator control. The finished roll is discharged to a roll upender, and the rolls are stored on end (7). Portions of this system are shown in Figure 37.

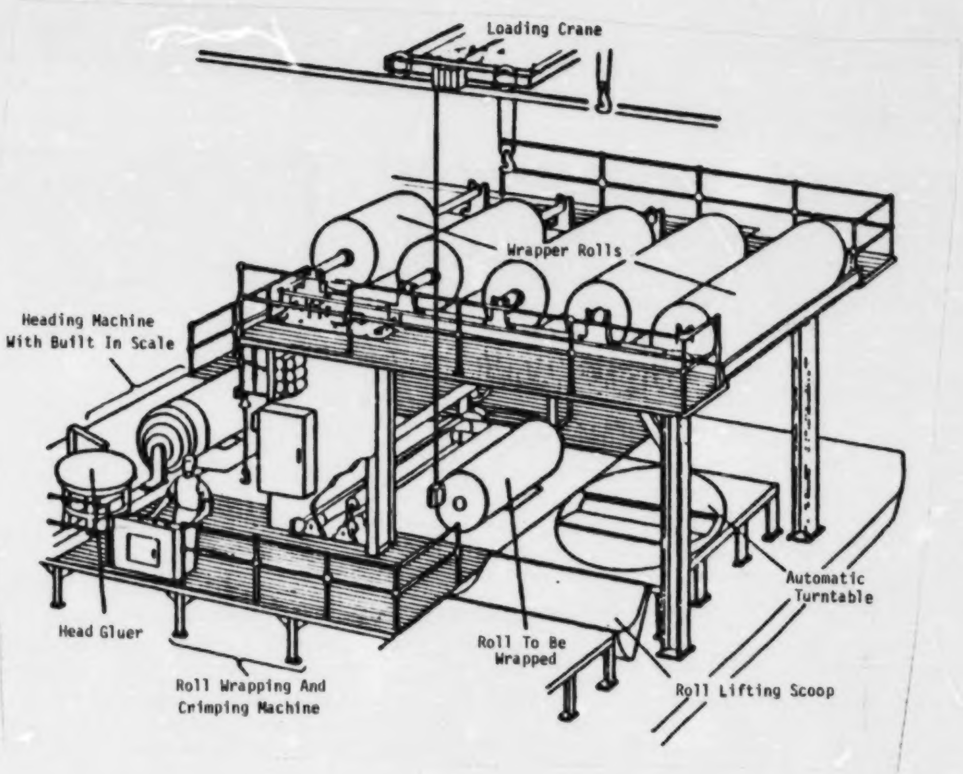


Figure 37 Roll Finishing System

For paper sheets, ream-sealing machines are used. Trimmed sheets are transferred to a cart, which is part of a conveyor system that accumulates stacks of trimmed paper for hand feeding to the ream-sealing machines. These machines are often equipped with a labeling device, so that reams can be loaded directly into cartons for shipping (7).

The principal wastewater discharges from papermaking are as follows:

- Excess white water from seal pits or other tank overflows
- Rejects from stock cleaning devices (centrifugal cleaners, screens, and junk traps)
- Felt and wire cleaning waters
- Spills, washups, discharge of tank dregs, and other nonequilibrium losses

- Cooling water discharges
- Boiler blowdown and other miscellaneous discharges

Data breakdowns on these individual discharges are not available because of sewer interconnections and reuse complications at most mills.

Sources of BOD_5 in papermaking wastewaters are the organic raw materials used as the constituents of paper. Cellulose is foremost, constituting 80% or more of the weight of most papers. Rosin sizing and starch or protein adhesives also contribute to BOD_5 loadings, as do many special organic chemicals such as wet strength resins. Some or all of these constituents, including cellulose fibers, are in the solid or precipitated state, and therefore also contribute to TSS loadings. Fillers and coating pigments such as clay and titanium dioxide are responsible for virtually no BOD_5, but add to TSS loadings.

The combined papermaking effluents vary with the grade of paper produced. The ranges of effluent characteristics for nonintegrated paper and paperboard mills, indicated by data developed during this study, are presented in Table 46.

Table 46 EFFLUENT CHARACTERISTICS OF PAPER AND PAPERBOARD MAKING

Subcategory		pH	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Fine Papers	(Range)		3.3-26	2.6-124	12-138
	(Mean)		9.6	31	56
Tissue Papers	(Range)		0.7-23	4.1-72	18-287
	(Mean)		12	37	85
Tissue from Wastepaper	(Range)		5.2-23	9.2-133	0.2-288
	(Mean)		13	41	57
Light Weight	(Range)		0.2-58	0.1-151	11-750
	(Mean)		15	46	267
Filter and Nonwoven	(Range)		3.6-25	0.7-156	6.6-408
	(Mean)		9.8	39	172
Paperboard	(Range)		0.8-88	0.4-137	30-273
	(Mean)		10	42	102
GENERAL PAPERMAKING	(Range)	4.3-9	0.2-88	0.1-156	0.2-750
	(Mean)	5	8	23	54

In Table 47, priority and nonconventional pollutants measured in nonintegrated paper and paperboard making effluent streams are presented for subcategories in this study area where data are available. Many of these streams are treated with primary and biological effluent treatment systems which are discussed more fully in Appendix C.

BUILDING PAPER AND BOARD MAKING (STUDY AREA 10)

The basic process of building paper and board (including roofing felt) making is very similar to that described for non-integrated paper and paperboard making. In Figure 38, a process flow diagram is presented for building paper and roofing felt processing. In this flow diagram process control measures are labeled as they are presented in Table 48. In Appendix B, these process control measures are further described.

Fibers are prepared for use by various methods which are determined by the fiber source. Wood chips are pulped mechanically in an attrition mill. This is a refiner containing fixed and rotating discs between which the chips pass on a stream of water. In some operations, this is preceded by cooking, or steaming, the chips with water for a short period in a digester, a large metal pressure vessel. This softens the chips and reduces the mechanical energy required. Chemicals are not generally utilized (8).

The pulp is discharged from the attrition operation as a slurry which goes to a stock chest for storage. It is then blended with other raw materials. Wood flour requires no pretreatment and enters the system in the blending chest.

After they are cut and shredded, rags are placed, along with fresh or process water, in a beater tank at about 6% consistency. Here a rotating cylindrical bladed element, which operates in conjunction with stationary blades, impacts the fiber and causes its continuous circulation around the beater and back through the attrition zone. Thus, progressive fiberizing occurs. After a period of several hours, when the charge is sufficiently defibered, the pulp is diluted and removed to a dump chest.

Waste paper is similarly treated in beaters or pulpers. In the pulper operation, the paper follows the water circulation in a large open vat and is repeatedly exposed to rotating impeller blades. Over a period of time it is ripped, shredded, and finally defibered, as illustrated in Figure 39. Accessory equipment separates and removes metal and other contaminants.

After the stock is blended, it is subjected to refining and screening ahead of the forming process. Some building papers are highly sized with resins and alum. Felts may be sized with bituminous materials or contain moldproofing or fungicidal materials.

These products are manufactured principally on single-cylinder paper machines from the raw materials reduced to fiber in the stock preparation area and transported to the machine in a dilute slurry. A rotating wire-covered cylinder retains the fibers which form a sheet on its surface

Table 47 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN PAPER AND PAPERBOARD MAKING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/l)				Percent Reduction	Treatment Type
		Untreated	(Raw)	Treated	(Final)		
		Range	Average	Range	Average		
Benzene	(TW)	0	0	0-1	1	0	Biological
	(TW)	0-1	1	0	0	100	Primary
	(FP)	0	0	0	0	--	Biological
	(FP)	0-1	1	0-2	1	0	Primary
	(FN)	0	0	0	0	--	Biological
	(FN)	0	0	0-4	1	0	Primary
	(P)	0-4	1	0-2	1	0	Biological
1,2-Dichloroethane	(FP)	0-2	1	1-2	2	0	Biological
	(FP)	0	0	0	0	--	Primary
Chloroform	(TW)	0-9	3	0	0	100	Biological
	(TW)	0	0	0-1	1	0	Primary
	(FP)	0-26	6	0-6	3	50	Biological
	(FP)	4-9	7	4-6	5	28.6	Primary
	(TP)	2-4	3	4	4	0	Primary
	(TP)	0	0	0	0	--	Biological
	(LW)	15-21	27	2-3	3	88.9	Biological
Ethylbenzene	(TW)	2-74	27	0	0	100	Biological
	(TW)	0-5	2	0	0	100	Primary
	(TP)	54-39000	13081	36-300	149	98.9	Primary
	(TP)	0	0	0	0	--	Biological
	(FN)	0-2	1	0	0	100	Biological
	(FN)	0	0	0	0	--	Primary
	(P)	2-6	3	0-2	1	66.7	Biological
Methylene Chloride	(TW)	17-410	174	0	0	100	Biological
	(TW)	1-11	5	0-4	2	60	Primary
	(FP)	0-1	1	0-1	1	0	Biological
	(FP)	0-17	7	5-8	7	0	Primary
	(LW)	0-2	1	0-2	1	100	Biological
	(P)	0-3	1	0	0	100	Biological
Naphthalene	(TW)	0	0	0	0	--	Biological
	(TW)	16-43	26	0-27	18	30.8	Primary
Phenol	(TW)	4-140	41	0-6	2	95.1	Biological
	(TW)	0	0	0	0	--	Primary
	(FP)	44-150	94	22-66	38	58.6	Primary
	(FP)	0-25	6	0	0	100	Biological
	(TP)	1-11	5	0-9	4	20	Biological
	(TP)	0-2	1	0-3	2	0	Primary
	(LW)	0-4	2	0-3	2	0	Biological
	(FN)	0	0	0-17	10	0	Primary
	(FN)	8-150	64	0-3	1	98.4	Biological
	(P)	2-10	6	0-3	2	66.7	Biological
Bis(2-Ethylhexyl) Phthalate	(TW)	3-5	4	0-1	1	75	Primary
	(TW)	0-19	10	0-8	3	70	Biological
	(FP)	410-2500	1193	28-2494	869	27.2	Primary
	(FP)	0-13	3	0-25	6	0	Biological
	(TP)	8-73	30	8-38	23	23.3	Biological
	(TP)	6-13	8	0-13	7	12.5	Primary
	(LW)	4-7	5	6-7	7	0	Biological
	(FN)	0-1	1	0-4	2	0	Primary
	(FN)	14-160	85	13-61	31	63.5	Biological
	(P)	4-31	11	0-7	2	81.8	Biological

Table 47 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN PAPER AND PAPERBOARD MAKING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (µg/l)				Percent Reduction	Treatment Type
		Untreated	(Raw)	Treated	(Final)		
		Range	Average	Range	Average		
Butyl Benzyl Phthalate	(TP)	620-950	797	0-15	5	99.4	Primary
	(TP)	0	0	0	0	--	Biological
Di-n-Butyl Phthalate	(TW)	0	0	0	0	--	Primary
	(TW)	0-17	6	0	0	100	Biological
	(TP)	0-3	1	0	0	100	Primary
	(TP)	0	0	0	0	--	Biological
	(LW)	0-3	1	0-5	2	0	Biological
	(FN)	0	0	0-2	1	0	Primary
	(FN)	0	0	0	0	--	Biological
	(P)	110-230	180	0-61	20	88.9	Biological
Diethyl Phthalate	(TW)	0	0	0	0	--	Primary
	(TW)	0-55	26	0	0	100	Biological
	(TP)	0-35	12	0	0	100	Primary
	(TP)	0	0	0	0	--	Biological
	(P)	0-12	4	0-130	58	0	Biological
Tetrachloroethylene	(TW)	0-220	74	0-57	19	74.3	Primary
	(TW)	0	0	0	0	--	Biological
	(TP)	0	0	8-9	8	0	Primary
	(TP)	0	0	0	0	--	Biological
	(P)	2-4	3	0	0	100	Biological
Toluene	(TW)	0-4	2	0-8	2	0	Biological
	(TW)	0-2	1	0	0	100	Primary
	(FP)	0	0	1-2	2	0	Biological
	(FP)	0	0	0	0	--	Primary
	(TP)	2-380	130	1-15	6	95.4	Primary
	(TP)	0	0	0	0	--	Biological
	(LW)	0-5	2	0-2	1	50	Biological
	(FN)	0-6	2	0	0	100	Biological
	(FN)	0	0	0	0	--	Primary
	(P)	0-5	2	0-1	1	50	Biological
PCB-1254	(TW)	0-<1	<1	0-<1	<1	--	Biological
	(TW)	0	0	0	0	--	Primary
	(FP)	0-<1	<1	0	0	100	Primary
	(FP)	0	0	0	0	--	Biological
	(FN)	0-28	9	0	0	100	Primary
	(FN)	0	0	0	0	--	Biological
Chromium	(TW)	<2-63	20	<2-28	13	35	Biological
	(TW)	8-27	17	5	5	70.6	Primary
	(FP)	<1-6	3	<1	<1	>66.7	Biological
	(FP)	1-8	5	<2-3	2	60	Primary
	(TP)	<1-2	2	<2-3	2	0	Biological
	(TP)	22-23	23	<2	<2	>91.3	Primary
	(LW)	2-4	3	0-3	2	33.3	Biological
	(FN)	<1-1	1	<1-2	1	0	Primary
	(FN)	5-8	6	<1-4	3	50	Biological
	(P)	5-1800	675	<2-13	6	99.1	Biological
Copper	(TW)	24-100	55	3-110	47	14.5	Biological
	(TW)	8-15	13	<2-18	8	38.5	Primary
	(FP)	<1-20	13	<1-81	18	0	Biological
	(FP)	6-62	43	16-26	19	55.8	Primary

Table 47 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN PAPER AND PAPERBOARD MAKING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/1)				Percent Reduction	Treatment Type
		Untreated	(Raw)	Treated	(Final)		
		Range	Average	Range	Average		
Copper (Continued)	(TP)	17-25	22	15-33	25	12	Biological
	(TP)	65-88	74	13-17	14	81.1	Primary
	(LW)	10-54	37	0-<10	4	89.2	Biological
	(FN)	14-28	19	9-10	10	47.4	Primary
	(FN)	6-120	61	6-13	9	85.2	Biological
	(P)	17-300	78	<1-10	4	94.9	Biological
Cyanide	(TW)	<10	<10	<10	<10	--	Biological
	(TW)	<10	<10	<10	<10	--	Primary
	(LW)	<10	<10	<10	<10	--	Biological
	(FN)	<10-13	11	<10	<10	>9.1	Biological
	(FN)	0	0	0	0	--	Primary
	(P)	<10-1650	310	<10-80	26	91.6	Biological
Lead	(TW)	4-120	44	4-120	38	13.6	Biological
	(TW)	<2-8	5	<2-3	2	60	Primary
	(FP)	<1-8	3	<1-5	3	0	Biological
	(FP)	<1-10	5	6-21	13	0	Primary
	(TP)	<1-<2	<2	<2	<2	--	Biological
	(TP)	<2-32	14	<2	<2	>85.7	Primary
	(LW)	5-12	9	0-<1	<1	>88.9	Biological
	(FN)	<1-22	8	<1-1	1	87.5	Primary
	(FN)	1-6	4	<2-10	6	0	Biological
	(P)	<2-9000	3334	<2-20	9	99.8	Biological
Mercury	(TW)	0.6-1.2	1	<0.5-0.9	0.8	20	Primary
	(TW)	<0.5-1.2	0.6	<0.5-2.0	0.8	0	Biological
	(FP)	<0.5	<0.5	<0.5	<0.5	--	Primary
	(FP)	<0.5-0.8	0.6	<0.5-0.7	0.6	--	Biological
	(TP)	<0.5	<0.5	<0.5	<0.5	--	Biological
	(TP)	<0.5	<0.5	<0.5	<0.5	--	Primary
	(LW)	<0.5	<0.5	<0.5	<0.5	--	Biological
	(FN)	<0.5	<0.5	<0.5	<0.5	--	Primary
	(FN)	<0.5	<0.5	<0.5	<0.5	--	Biological
	(P)	<0.5	<0.5	<0.5	<0.5	--	Biological
Nickel	(TW)	5-25	15	2-6	3	80	Primary
	(TW)	2-92	21	3-25	13	38.1	Biological
	(FP)	<2-12	5	<2	<2	>60	Primary
	(FP)	<1-10	5	<1-13	6	0	Biological
	(TP)	<2	<2	<2-3	2	0	Biological
	(TP)	<2-2	2	<2	<2	>1	Primary
	(LW)	<2	<2	0-<2	<1	50	Biological
	(FN)	<1	<1	<1-3	2	0	Primary
	(FN)	<1-3	2	<1- 2	<1	>50	Biological
	(P)	<2-29	13	2-10	5	61.5	Biological
Zinc	(TW)	52-59	54	22-33	27	50	Primary
	(TW)	31-3560	677	<5-183	88	87	Biological
	(FP)	49-91	71	75-160	118	0	Primary
	(FP)	6-185	55	<3-35	18	67.3	Biological
	(TP)	52000-54000	53300	60-140	88	99.8	Biological
	(TP)	46-160	92	19-29	23	75	Primary
	(LW)	12-22	16	0-8	4	75	Biological
	(FN)	11-15	13	9-17	12	7.7	Primary

Table 47 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN PAPER AND PAPERBOARD MAKING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/l) Untreated (Raw) Range	Concentration (μg/l) Untreated (Raw) Average	Concentration (μg/l) Treated (Final) Range	Concentration (μg/l) Treated (Final) Average	Percent Reduction	Treatment Type
Zinc (Continued)	(FN)	118-193	159	40-66	56	64.8	Biological
	(P)	72-2050	710	<5-210	72	89.9	Biological
Abietic Acid	(TW)	0-150	54	0	0	100	Biological
	(TW)	120-260	203	35-140	84	58.6	Primary
	(FP)	0-660	207	0-18	6	97.1	Biological
	(FP)	0	0	0	0	--	Primary
	(TP)	39-75	53	0	0	100	Primary
	(TP)	0	0	0	0	--	Biological
	(P)	0-1800	748	0	0	100	Biological
Dehydroabietic Acid	(TW)	150-840	342	0-37	20	94.6	Biological
	(TW)	220-650	417	160-300	250	40	Primary
	(FP)	58-720	433	17-66	45	89.6	Biological
	(FP)	160-660	483	49-150	93	80.7	Primary
	(TP)	190-230	213	85-112	98	54	Primary
	(TP)	0	0	0	0	--	Biological
	(FN)	0-50	33	0	0	100	Biological
	(FN)	0	0	0	0	--	Primary
	(P)	110-780	418	0-180	64	84.5	Biological
Isopimaric Acid	(TW)	21-43	32	0	0	100	Biological
	(TW)	13-45	28	0	0	100	Primary
	(FP)	8-140	39	0	0	100	Biological
	(FP)	0	0	0	0	--	Primary
	(TP)	23-46	37	0-6	2	94.6	Primary
	(TP)	0	0	0	0	--	Biological
	(P)	8-190	62	0	0	100	Biological
Pimaric Acid	(TW)	2-18	12	0	0	100	Biological
	(TW)	18-78	43	0	0	100	Primary
	(FP)	0-40	19	0	0	100	Biological
	(FP)	0	0	0	0	--	Primary
	(TP)	0-15	10	0	0	100	Primary
	(TP)	0	0	0	0	--	Biological
	(P)	22-29	25	0	0	100	Biological
Oleic Acid	(TW)	98-270	183	0-310	193	0	Biological
	(TW)	81-200	147	0-74	25	83	Primary
	(FP)	55-80	65	0	0	100	Biological
	(FP)	0	0	0	0	--	Primary
	(TP)	210-290	260	0-61	27	89.6	Primary
	(TP)	4-29	13	0-47	27	0	Biological
	(P)	250-270	260	0	0	100	Biological
Linoleic Acid	(FP)	0-200	67	0	0	100	Biological
	(FP)	0	0	0	0	--	Primary
	(FN)	0	0	0-9	3	0	Biological
Xylenes	(TW)	0-140	28	0-13	2	92.9	Biological
	(TW)	0-31	10	0	0	100	Biological
	(TP)	140-37000	13547	160-1600	800	94.1	Primary
	(TP)	0	0	0	0	--	Biological
	(LW)	0-8	5	0	0	100	Biological
	(P)	5-14	8	1-4	3	62.5	Biological

Table 47 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN PAPER AND PAPERBOARD MAKING EFFLUENT STREAMS (1)

Chemical	(Subcategory)	Concentration (μg/l) Untreated	(Raw)	Treated	(Final)	Percent	Treatment
		Range	Average	Range	Average	Reduction	Type
Color	(TW)	<5-470[a]	88	14-50[a]	31	64.8	Biological
	(TW)	5-40[a]	23	14-50[a]	38	0	Primary
	(FP)	<5[a]	<5	<5[a]	<5	--	Biological
	(FP)	48-830[a]	311	6-82[a]	34	89.1	Primary
	(TP)	<5[a]	<5	<5[a]	<5	--	Biological
	(TP)	<5[a]	<5	<5[a]	<5	--	Primary
	(LW)	<5[a]	<5	<5[a]	<5	--	Biological
	(FN)	<5[a]	<5	<5[a]	<5	--	Primary
	(FN)	10-100[a]	43	<5-20[a]	10	76.7	Biological
	(P)	<5-14[a]	7	0-50[a]	15	0	Biological
COD	(TW)	230-500[b]	363	170-220[b]	192	47.1	Biological
	(TW)	160-250[b]	190	110-156[b]	131	31.1	Primary
	(FP)	87-220[b]	168	73-110[b]	87	48.2	Biological
	(FP)	254-763[b]	437	22-26[b]	25	94.3	Primary
	(TP)	16-20[b]	18	85-110[b]	95	0	Biological
	(TP)	26-666[b]	399	102-142[b]	119	70.2	Primary
	(LW)	230-475[b]	313	45-90[b]	69	78	Biological
	(FN)	77-136[b]	104	13-57[b]	28	73.1	Primary
	(FN)	230-250[b]	240	40-56[b]	49	79.6	Biological
	(P)	<5-370[b]	230	12-97[b]	46	80	Biological

Subcategory Key: FP - Fine Papers
FN - Filter and Nonwoven
LW - Light Weight
P - Paperboard
TP - Tissue Papers
TW - Tissue from Wastepaper

[a] Color concentrations given in platinum cobalt units
[b] COD concentrations given in mg/l

Table 48 BUILDING PAPER AND BOARD MAKING PROCESS CONTROL MEASURES

Process Component	Control Measure Description	
Saveall	21	Improve saveall
White Water System	24	Paper machine white water showers for wire cleaning
Effluent	35	Recycle of effluent

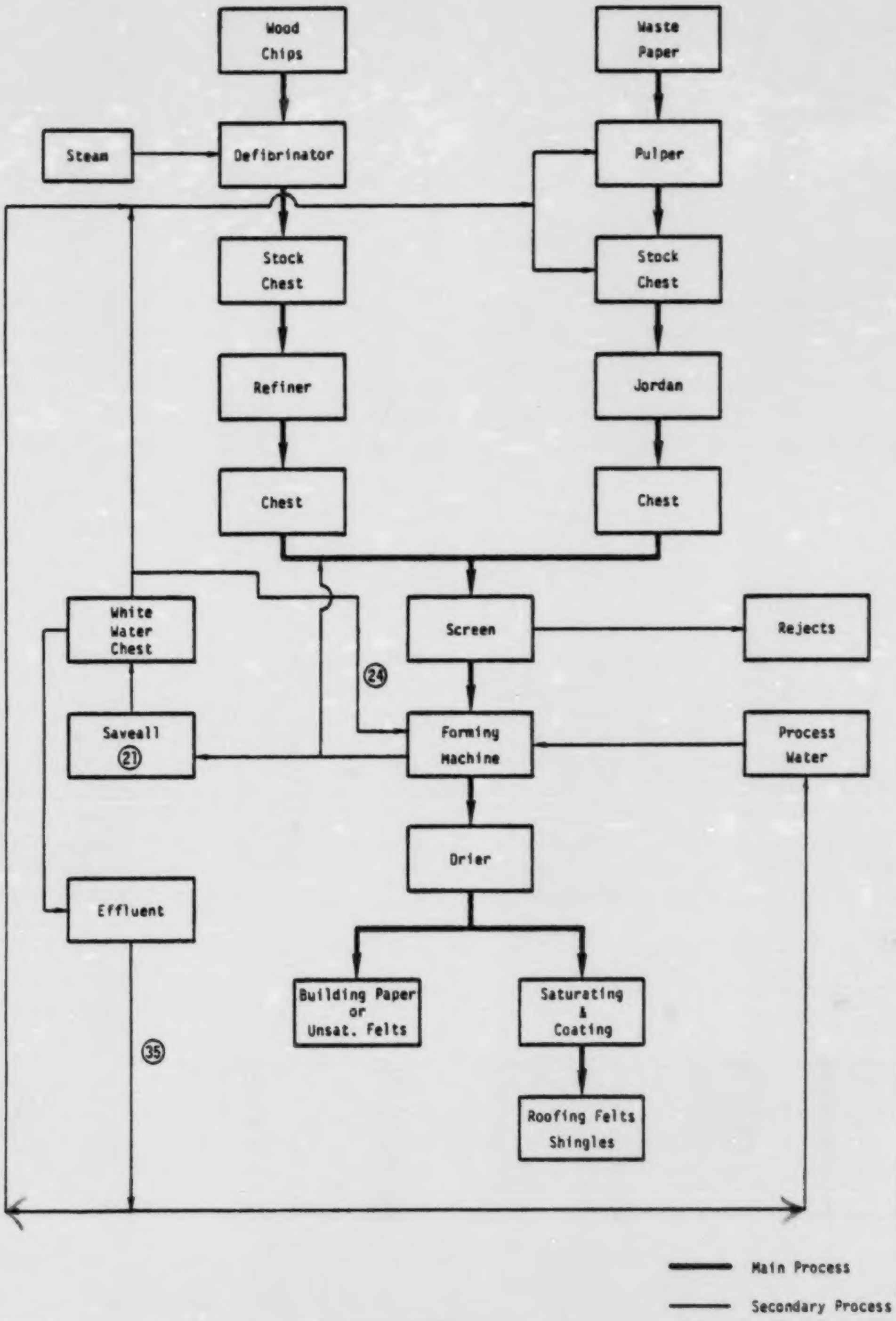


Figure 38 Building Paper and Roofing Felt Process Diagram

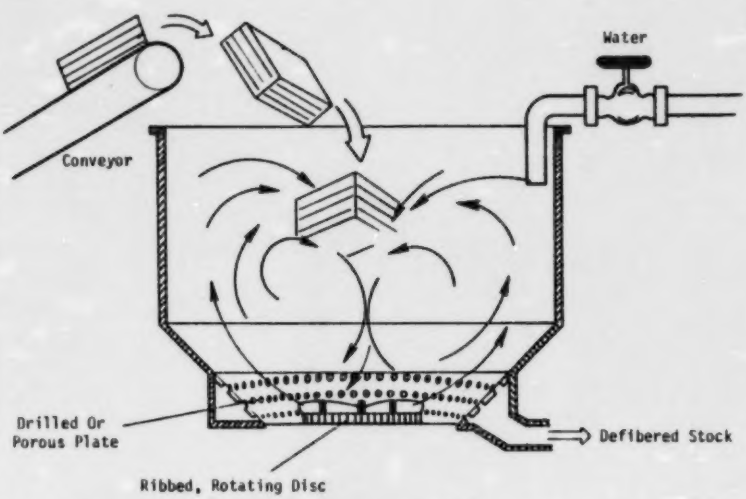


Figure 39 Pulper Design

and permits water to drain through. This sheet is then removed from the wire by a cloth felt which carries it through a press section where additional water is removed from the sheet. It is self supporting as it leaves the press sections and passes through the steam-heated multi-drum drier section from which it is cut to width and rolled. At this stage it is considered a dry or unsaturated felt.

In this study area, a variety of construction building papers, such as roofing felt and shingles are produced for the building trade. The typical mill utilizes predominantly mixed waste paper for its furnish, which is generally very low grade material, consisting of some corrugated and a great deal of mixed waste. In Table 49, the range of effluent characteristics at building paper and board making plants is presented. Raw waste loads in this study area are generally among the lowest in the industry, since quality requirements in most of the products are very minimal and the opportunity therefore exists for recycling and reusing sludge and effluents in the final product.

In Table 50, priority and nonconventional pollutants measured in the effluent streams of building paper producers are presented. Effluent treatment systems used include primary treatment systems and POTW's which are described more fully in Appendix C.

MOLDED WASTE PAPER PROCESSING (STUDY AREA 11)

Molded pulp products are made by depositing fibers from a pulp slurry onto a perforated mold. The deposition can be achieved either by applying

Table 49 EFFLUENT CHARACTERISTICS OF BUILDING PAPER AND BOARD MAKING

	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Range	1.7-33	0.2-72	0.4-65
Mean	8.4	12	14

pressure to the pulp slurry or creating a vacuum behind the mold. The result is a soft, low-density product that is relatively strong and rigid. Molded pulp products can be made into a wide variety of shapes and sizes, including such contour forms as egg cartons.

While these operations utilize a furnish prepared from waste paper, some grades also incorporate filler and sizing materials, as would many types of heavier paper products. However, these operations do not utilize fourdrinier papermachines; typically, they utilize forming machines on which several vacuum pick-up forming dies are located. The individual products are formed in one operation, pressed and then subsequently dried in drying ovens.

Such operations typically involve a dispersion process using warm recycled papermachine whitewater, followed by coarse screening to remove gross contamination and debris which may have been received with the waste paper. More extensive fine screening and centrifugal cleaners may-then be used before the papermaking step. Higher quality grades may require segregated waste paper and a more extensive preparation system, usually including a deinking system. In Figure 40, a molded waste paper process flow diagram is presented and includes two process control measures for the reduction of waste loads and effluent. These measures which are presented in Table 51 are further discussed in Appendix B.

In Table 52 the range of effluent characteristics at molded waste paper producers is presented. In terms of water use, operations are simple compared to most papermaking systems. Effluent loads vary widely due to the degree of self containment in operations throughout this study area. The high water usage per ton generally correlates with the low production capabilities of a producer. While some mills use 100% waste paper in their furnish, others incorporate varying amounts of purchased pulp.

In Table 53, priority and nonconventional pollutants analyzed in the effluent streams of molded waste paper producers are presented. The treatment systems employed by these producers (Biological, POTW) are discussed more fully in Appendix C.

Table 50 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN BUILDING PAPER EFFLUENT STREAMS (1)

Chemical	Concentration (µg/l) Untreated (Raw) Range	Concentration (µg/l) Untreated (Raw) Average	Concentration (µg/l) Treated (Final) Range	Concentration (µg/l) Treated (Final) Average	Percent Reduction	Treatment Type
Benzene	0-4	1	*	--	--	POTW
	0	0	0	0	--	Primary
1,1,1-Trichloroethane	0-20	7	*	--	--	POTW
	0	0	0	0	--	Primary
Chloroform	2-21	10	*	--	--	POTW
	0	0	0	0	--	Primary
Ethylbenzene	1-11	5	*	--	--	POTW
	0	0	0	0	--	Primary
Methylene Chloride	0-6	2	*	--	--	POTW
	0	0	0	0	--	Primary
Dichlorobromomethane	0-14	5	*	--	--	POTW
	0	0	0	0	--	Primary
Trichlorofluoromethane	0-8	3	*	--	--	POTW
	0	0	0	0	--	Primary
Dibromochloromethane	0-5	2	*	--	--	POTW
	0	0	0	0	--	Primary
Pentachlorophenol	17-160	65	*	--	--	POTW
	0	0	0	0	--	Primary
Phenol	1100-1400	1233	1200-1700	1433	--	Primary
	51-280	134	*	--	--	POTW
Bis(2-Ethylhexyl)Phthalate	5-80	35	*	--	--	POTW
	0	0	0	0	--	Primary
Butyl Benzyl Phthalate	0	0	0	0	--	Primary
	5-12	9	*	--	--	POTW
Di-n-Butyl Phthalate	0	0	0	0	--	Primary
	0-25	9	*	--	--	POTW
Diethyl Phthalate	0	0	0	0	--	Primary
	0-180	29	*	--	--	POTW
Tetrachloroethylene	0-2	1	*	--	--	POTW
	0	0	0	0	--	Primary
Toluene	0-620	81	*	--	--	POTW
	0	0	0	0	--	Primary
Trichloroethylene	0-38	11	*	--	--	POTW
	0-2	1	0	0	100	Primary
PCB-1254	0-<1	<1	*	--	--	POTW
	0	0	0	0	--	Primary
PCB-1248	0-7	4	*	--	--	POTW
	0	0	0	0	--	Primary
Chromium	24-250	81	*	--	--	POTW
	290-370	337	230-350	290	13.9	Primary
Copper	30-270	145	*	--	--	POTW
	185-210	202	87-97	93	54	Primary
Cyanide	90-1200	368	*	--	--	POTW
	25-170	108	25-190	117	0	Primary
Lead	36-880	264	*	--	--	POTW
	210-360	273	50-190	137	49.8	Primary
Mercury	<0.5	<0.5	<0.5	<0.5	--	Primary
	<0.5-1	0.6	*	--	--	POTW
Nickel	84-160	115	100-140	120	0	Primary
	12-65	40	*	--	--	POTW

Table 50 (Continued) PRIORITY AND NONCONVENTIONAL POLLUTANTS IN BUILDING PAPER EFFLUENT STREAMS (1)

Chemical	Concentration (µg/l)				Percent Reduction	Treatment Type
	Untreated Range	(Raw) Average	Treated Range	(Final) Average		
Zinc	2500-3000	2800	1900-2900	2400	14.3	Primary
	5-2100	999	*	--	--	POTW
Abietic Acid	930-14000	7559	*	--	--	POTW
	0	0	0	0	--	Primary
Dehydroabietic Acid	670-6000	2199	*	--	--	POTW
	110-170	143	60-200	117	18.2	Primary
Isopimaric Acid	160-3000	1165	*	--	--	POTW
	0	0	0	0	--	Primary
Pimaric Acid	130-1600	576	*	--	--	POTW
	0	0	0	0	--	Primary
Oleic Acid	830-3500	2237	*	--	--	POTW
	0	0	0	0	--	Primary
Linoleic Acid	0-3600	897	*	--	--	POTW
	0	0	0	0	--	Primary
Linolenic Acid	84-170	138	*	--	--	POTW
	0	0	0	0	--	Primary
Xylenes	3-63	18	*	--	--	POTW
	0-28	14	0-32	16	0	Primary
Color	370-1980[a]	936	*	--	--	POTW
	7600-8300[a]	8000	7400-8300[a]	8000	0	Primary
COD	2560-5120[b]	3923	*	--	--	POTW
	11800-19500[b]	16667	16100-24300[b]	19133	0	Primary

[a] Color concentrations given in platinum cobalt units

[b] COD concentrations given in mg/l

*No sample taken

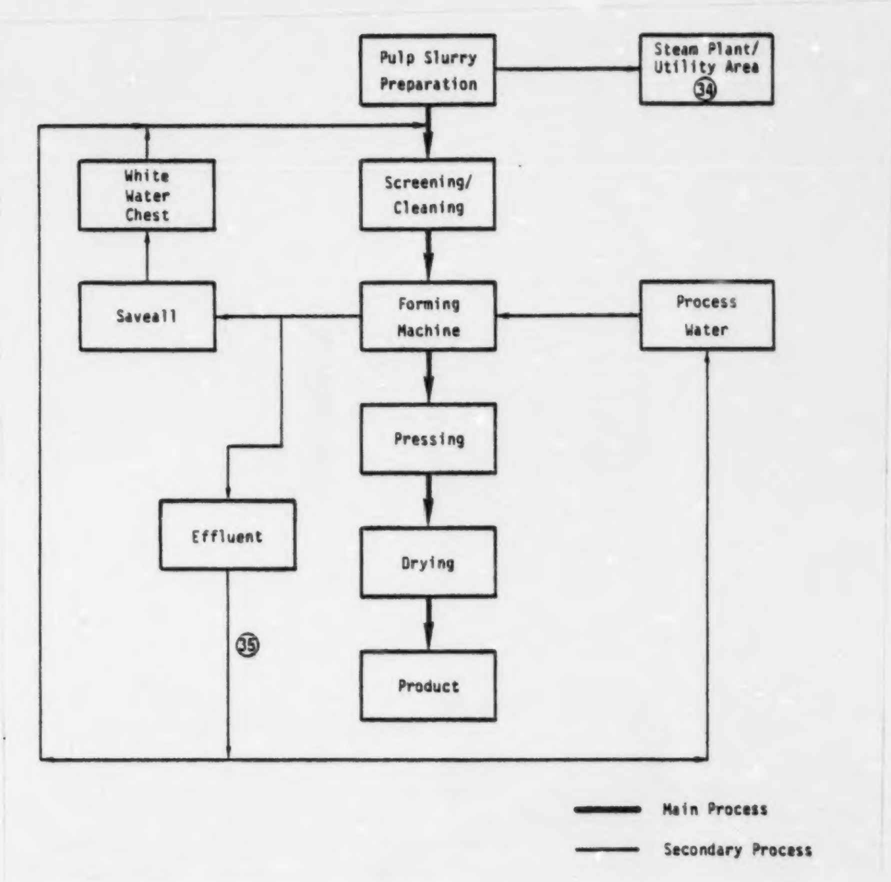


Figure 40 Molded Waste Paper Process Flow Diagram

Table 51 MOLDED WASTE PAPER PROCESS CONTROL MEASURES

Process Area		Control Measure Description
Steam Plant and Utility Areas	34	Lagoon for boiler blowdown and backwash waters
Effluent	35	Recycle of effluent

Table 52 EFFLUENT CHARACTERISTICS OF MOLDED WASTEPAPER PROCESSING

	BOD kg/kkg	TSS kg/kkg	Water Usage kl/kkg
Range	0.2-16	0.5-24	19-109
Mean	6.5	11	53

Table 53 PRIORITY AND NONCONVENTIONAL POLLUTANTS IN MOLDED WASTEPAPER PROCESSING EFFLUENT STREAMS (1)

Chemical	Concentration (µg/l)				Percent Reduction	Treatment Type
	Untreated (Raw)		Treated (Final)			
	Range	Average	Range	Average		
Methylene Chloride	0-2	1	0-1	1	0	Biological
	0	0	*	--	--	POTW
Pentachlorophenol	0-6	2	0-4	1	50	Biological
	0	0	*	--	--	POTW
Phenol	4-8	6	*	--	--	POTW
	7-9	8	0-3	1	87.5	Biological
Bis(2-Ethylhexyl)Phthalate	11-18	14	*	--	--	POTW
	1-4	3	0-2	1	66.7	Biological
Chromium	5-14	9	3-4	3	66.7	Biological
	<2-8	5	*	--	--	POTW
Copper	3-34	16	2-5	4	75	Biological
	25-44	37	*	--	--	POTW
Cyanide	<10	<10	<10	<10	--	Biological
	<10	<10	*	--	--	POTW
Lead	2-33	22	7-18	12	45.5	Biological
	<2-<20	<13	*	--	--	POTW
Mercury	<0.5	<0.5	*	--	--	POTW
	<0.5	<0.5	<0.5	<0.5	--	Biological
Nickel	<2-2	2	*	--	--	POTW
	10-48	23	<1-5	3	87	Biological
Zinc	120-330	200	*	--	--	POTW
	262-465	392	26-73	52	86.7	Biological
Abietic Acid	190-250	210	0-21	7	96.7	Biological
	540-680	633	*	--	--	POTW
Dehydroabietic Acid	340-530	453	2-170	61	86.5	Biological
	550-620	573	*	--	--	POTW
Isopimaric Acid	41-56	48	0	0	100	Biological
	80-120	94	*	--	--	POTW
Pimaric Acid	48-64	57	0	0	100	Biological
	0	0	*	--	--	POTW
Oleic Aicd	460-540	493	5-80	48	90.3	Biological
	340-360	353	*	--	--	POTW
Linoleic Acid	170-240	207	0	0	100	Biological
	110-150	123	*	--	--	POTW
Color	82-170[a]	121	23-810[a]	302	0	Biological
	<5-125[a]	53	*	--	--	POTW
COD	262-346[b]	291	66-101[b]	82	71.8	Biological
	560-880[b]	693	*	--	--	POTW

[a] Color concentrations given in platinum cobalt units
[b] COD concentrations given in mg/l
*No sample taken

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SECTION 6

OCCUPATIONAL EXPOSURE

In this section, available information on the sources and extent to which workers are exposed to specific chemicals and other significant material agents is reviewed. Known carcinogens to which workers may be exposed, as well as specific pulp and paper industry occupations involving exposure to carcinogens are identified. A review of accidents and fatalities due to chemical hazards and acute exposures is also presented, along with a description of human factors contributing to such chemical hazards. For those process and waste chemical species known to occur in concentrations high enough to promote a health risk, a discussion of health effects is presented. This discussion is intended to expound the identification of health effects of selected chemical agents presented in the Chemical Profiles (Appendix A). Worker activities, training programs and safety procedures designed to control or limit worker exposure throughout the industry are also discussed. Crewing and exposure patterns for specific study areas are discussed and a review of specific case studies is presented for which detailed information is available on the number of workers and their activities associated with various process and waste chemicals, near source chemical concentrations, effects of exposure during worker activities, use and misuse of protective equipment and procedures, as well as any conclusions and recommendations made during these investigations.

SOURCES AND EXTENT OF EXPOSURE

Pulp and paper industry workers are exposed to numerous chemical agents in the form of dusts, reduced sulfur emissions and other chemicals in vapor and liquid form. Wood dust exposures occur during chipping, grinding, log debarking, and pulp digester loading operations. Other dusts to which workers are commonly exposed include starch, cork, crepe, lime, alum, cotton, pigment and sulfur dusts (sulfite mills) (1). Many of these dusts are present during the mixing of coating and filler materials into a pulp slurry or when added to paper during finishing operations.

The major sources of reduced sulfur emissions to which workers are exposed include black liquor recovery furnaces, direct contact evaporators, brown stock washers, knotter hoods, black liquor oxidation vents, condensates strippers, smelt dissolving tanks, and lime kilns. The most significant of these emissions to worker health include hydrogen sulfide, methyl and other mercaptans, dimethyl sulfide, dimethyl disulfide and sulfur dioxide. Figure 41 shows the various emission points in the kraft process.

Other potentially toxic chemicals which may pose a health hazard include chlorine, chlorine dioxide, hypochlorite bleaching effluent, ammonia and turpentine, as well as a wide range of other organic and inorganic process chemicals and by-products, some of which have not been identified to date.

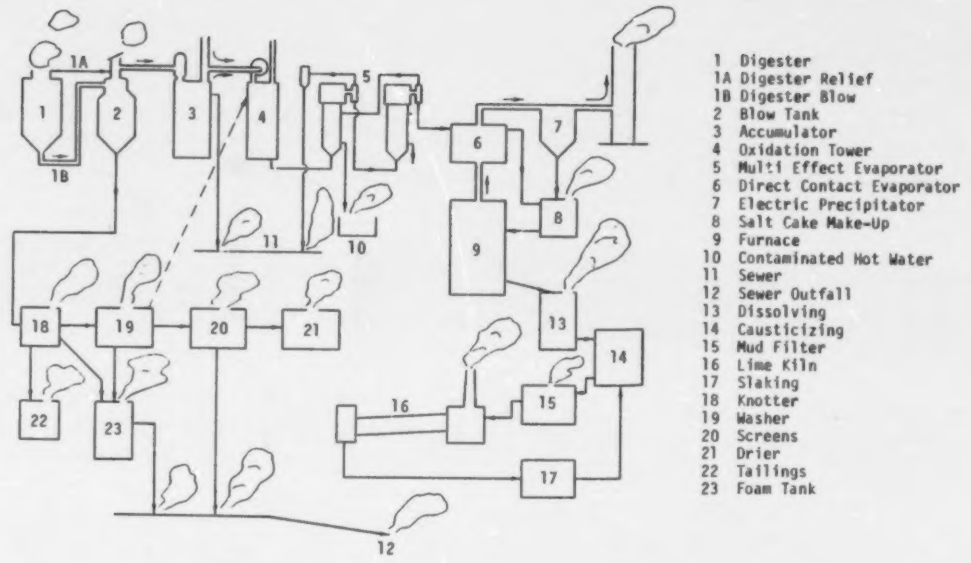

Figure 41 Odor Release in the Kraft Process

In Table 54, a list of potentially hazardous chemicals and related exposure points is presented for those work areas, processes and equipment which may contribute to significant exposure to workers in the pulp and paper industry.

Gas Concentrations in Kraft Mill Work Areas

The human nose is as sensitive to many sulfur containing gases as any instrument available. However, the nose cannot accurately assess concentrations of these gases. At present, gas chromatography is the only technique able to measure reliably and continuously individual sulfur containing gases at levels thought to exist in pulp mills. In a study initiated under the British Columbia Forest Industry, Industrial Health Research Program, gas chromatography techniques were used to develop an overall picture of gas concentrations in various work areas at a bleached kraft mill (2). In this investigation, 1,645 samples were collected and analyzed for sulfur containing gases from the 5 following locations:

- Brownstock washer area
- Batch digester area
- Low pressure chip feeder to the Kamyr digester

Table 54 CHEMICAL AND OCCUPATIONAL EXPOSURE POINTS IN PULP AND PAPER MILLS

Substance	Exposure Points	Use/Occurrence
Acetic Acid	NSSC pulping process liquor recovery	By-product recovered by acidification of spent liquor with sulfuric acid; dye solvents
Acrylamide	Blend chest; stock proportioning areas	Component of synthetic wet-end adhesives
Aluminum Sulfate	Beater; mixing vat; blend chest	Retention aid; papersizing; pH control of pulp stock; pitch control, waste treatment
Ammonia	Sulfite ammonia-base liquor preparation and recovery; coating area	Sulfite and NSSC raw material and effluent present in sulfite process areas; ingredient in paper coatings and adhesives
Asbestos	Blend chest; present in felt used on paper machines	Filler and coating material; pitch control and retention aid
Asphalt	Stock preparation areas	Basis for sizing agents and adhesives
Calcium Oxide	Sulfite pulping liquor preparation and recovery; kraft lime kiln, slaker, causticizer	Chemical make-up for white liquor generated in kraft process; calcium-base sulfite pulping
Carbon Black	Blend chest	Dye and coloring agent (paper and carbon paper)
Carbon Monoxide	Liquor recovery units and furnaces	Emission
Chlorine	Chemical bleaching operation	Bleaching agent and germicide; trace element in oil-fired power boilers
Chlorine Dioxide	Chemical bleaching operation (generated on-site)	Bleaching agent
Dimethyl Disulfide	Kraft digester, black liquor oxidizer, oxidizer, other components of kraft pulping system	Process emission
Dimethyl Sulfide	Kraft digester and other components of kraft pulping system	Process emission
Dimethyl Sulfoxide	Constituent of spent liquor from kraft pulping	Process emission
Formaldehyde	Blend chest; beater	Wet-strength agent
Hydrazine	Liquor recovery furnace	Corrosion inhibitor
Hydrogen Chloride	Chlorine dixoide preparation area	Possible input for on-site manufacture of chlorine dioxide
Hydrogen Peroxide	Mechanical or chemical bleaching operations	Oxidation mechanical bleaching agent; possible stage in chemical bleaching; bleaching and deinking of wastepaper
Hydrogen Sulfide	Alkaline pulp digesters; brown stock washers; black liquor storage and oxidation; sulfite liquor preparation area	Major kraft process emission; source of sulfur for sulfite liquor preparation
Kerosene	Paper machine area	Pitch and foam control agent
Magnesium Oxide	Sulfite liquor preparation and recovery processes	Pulping raw material
Methyl Alcohol	Chlorine dixoide preparation area	Possible input for on-site manufacture of chlorine dioxide
Methyl Mercaptan	Kraft pulping system and recovery furnace area	Process emission
Paraffin	Paper machine area	Coating material
Polychlorinated Biphenyls	Paper recycling and deinking operations	Formerly used as carrier in carbonless copy paper; final effluent
Rosin	Size press; blend chest	Sizing agent
Silica	Pulp stock area	Pigment filler/coating
Sodium Carbonate	NSSC, chemi-mechanical, sulfite and kraft pulping process areas	Sodium-base pulping chemical; recovery and make-up chemical in kraft pulping
Sodium Chloride	Chlorine dioxide preparation area	Possible input for on-site chlorine dioxide production; smelt from kraft recovery furnace
Sodium Hydroxide	May be found in all pulping and bleaching processes; deinking and chlorine dioxide preparation area	Pulping and bleaching; chlorine dioxide preparation; pH control; deinking
Sodium Hypochlorite	Chemical bleaching stage (following chlorine bleach)	Bleaching agent; oxidizer and germicide
Sodium Sulfate	Kraft, NSSC and mechanical pulping process areas	Recovery and make-up chemical in kraft process; pulping chemical for NSSC and mechanical pulps
Sulfur	Chemi-mechanical, NSSC and sulfite liquor preparation areas	Pulping base preparation
Sulfur Dioxide	Kraft pulping area; chlorine dioxide preparation area; mechanical bleach process; sulfite liquor preparation	Kraft and sulfite process emission; possible input for chlorine dioxide manufacture; bleaching agent; sulfite pulping chemical
Sulfuric Acid	Chlorine dioxide preparation area; kraft and sulfite process areas; papermaking process area; mechanical bleach area	Possible input for chlorine dioxide manufacturing; tall oil purification; by-product of sulfite pulping; sizing agent; pH control agent for mechanical bleaching
Talc	Paper machine area	Filler (printing paper and linerboard; pitch control agent)
Titanium Dioxide	Blend chest and beater	Coating/pigment
Trichloroethane	Papermaking area	Slime control agent; final effluent
Turpentine	Kraft digester	Pulping by-product
Zinc Oxide	Blend chest	Pigment, coating for photo-conductive reproduction paper

- Evaporators
- Bleach plant

Measured total reduced sulfur (TRS) and sulfur dioxide along with chlorine and chlorine dioxide gas levels, which differed at each location and fluctuated considerably with time, are summarized in Tables 55 and 56, respectively.

Brownstock washer area air samples were taken at the control panels on the operating floor. In this area, ventilation was provided by fans on the brownstock washer hoods and by a complete floor to ceiling opening at one end of the area. An example of results for the 319 analyses performed during 8 days of sampling is illustrated in Figure 42. Of these samples, only 10 contained measurable concentrations of sulfur dioxide (greater than 0.06 ppm); the highest SO_2 concentration was 0.2 ppm. Levels of hydrogen sulfide were generally below the detection limit of 0.001 ppm, with a maximum concentration 0.3 ppm. Methyl mercaptan concentrations were normally 0.1 - 0.3 ppm, with occasional peaks to 0.5 - 0.65 ppm. Dimethyl sulfide levels were usually between 0.1 and 0.5 ppm with occasional peaks to approximately 1 ppm.

Batch digester area gas concentrations are illustrated in Figure 43 for a 1 day sampling period. The highest concentrations of sulfur containing gases at the mill were measured at the chip loading area at the top of the batch digester. Sampling points were located near the digester cover (at head height) and near a wall opening over the blow tank vents.

Concentrations of hydrogen sulfide were normally below the minimum measurable level of 0.1 ppm, with maximum concentrations reaching 0.75 to 1 ppm. Sulfur dioxide was recorded in 1 sample at 0.2 ppm, otherwise SO_2 was not measured above the detection limit of 0.08 ppm. Methyl mercaptan concentrations were measured below 3 ppm in most cases, however, occasional peaks to a maximum of 7.3 ppm were detected. High concentrations of dimethyl sulfide were recorded periodically, as illustrated in Figure 42, with readings of more than 10 ppm occurring in 13 of the 323 samples obtained for this contaminant; most values were measured between 1 and 3 ppm. The normal range of dimethyl disulfide concentrations in the batch digester area was 0.01 - 0.5 ppm; the maximum value recorded was 0.85 ppm. Two composite samples taken in the batch digester area showed concentrations of turpentine vapor to be less than 1 ppm.

The low pressure chip feeder to the Kamyr (continuous) digester was sampled in a walk way approximately 2 meters from the chip feeder control valve, where ventilation was provided by an intermittently operated wall fan located above a door approximately 15 meters away from this location. Hydrogen sulfide concentrations were measured at less than 0.1 ppm throughout the sampling period, while sulfur dioxide was detected below the minimum measurable level of 0.04 ppm. Methyl mercaptan concentrations were generally less than 0.5 ppm, with occasional readings of 0.6 - 0.7 ppm; in one period of approximately 40 minutes, the methyl mercaptan concentration approached 2 ppm. Dimethyl sulfide concentrations in this location usually ranged from 0.1 to 0.7 ppm, with 9 of 213 samples measuring higher than 0.7 ppm; two of

Table 55 CONCENTRATIONS OF TRS/SO_2 GASES

Location	Concentration (ppm)									
	Hydrogen Sulfide		Sulfur Dioxide		Methyl Mercaptan		Dimethyl Sulfide		Dimethyl Disulfide	
	Normal Range	Maximum	Normal Range	Maximum	Normal Range	Maximum	Normal Range	Maximum	Normal Range	Maximum
Brownstock Washers	<0.1 - 0.2	0.3	ND (<0.06)	0.2	0.1 - 0.2	0.65	0.1 - 0.5	1.0	NM	NM
Batch Digesters	<0.1 - 0.3	1.0	ND (<0.08)	0.2	0.5 - 1.5	7.3	0.5 - 6.0	<64	<0.1 - 0.5	0.85
Low pressure chip feeder to Kamyr digester	<0.05 - 0.05	0.1	ND (<0.04)	0.2	0.1 - 0.4	1.8	0.1 - 0.7	1.9	NM	NM
Evaporator	ND (<0.001)	0.01	ND (<0.01)	0.08	<0.01	0.3	<0.004 - 0.05	0.4	NM	NM

ND - Not detectable   NM - Not measured

Double Lines

these samples contained approximately 2 ppm dimethyl sulfide. Sampling in this area was terminated after 68 hours due to the instrument cabinet being doused with black liquor spray, followed by a chip spill that buried it and, finally, a power failure.

Table 56 CHLORINE AND CHLORINE DIOXIDE CONCENTRATIONS

Bleach Plant	Concentration (ppm) Chlorine Normal Range	Concentration (ppm) Chlorine Maximum	Concentration (ppm) Chlorine Dioxide
C-Stage Washer	0.2-0.4	0.9	ND
Hypochlorite Pump Room	0.3-0.8	0.8	ND
D_1-Stage Washer	0.1-0.2	0.2	ND
C-Stage Recycle Pump	1.7-2.2	4.1	ND
Chlorine Dioxide Generator	0.2-0.3	0.3	ND

ND - Not Detectable

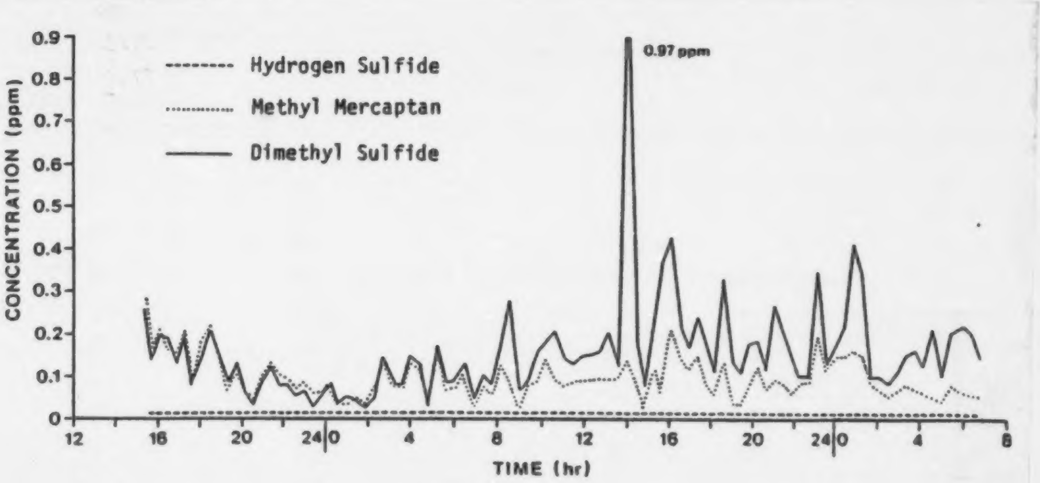

Figure 42 TRS Gas Concentrations, Brownstock Washer Area

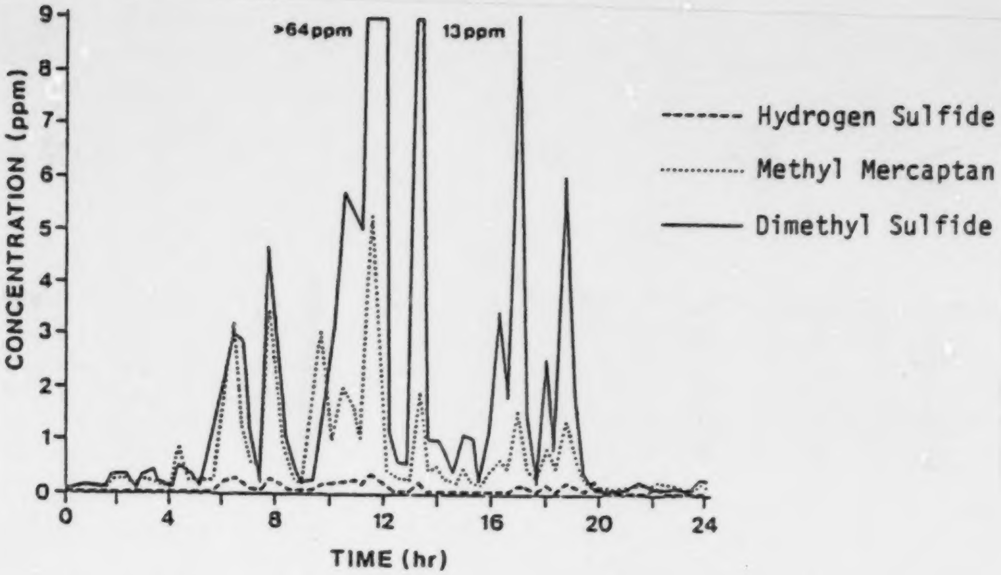

Figure 43 TRS Gas Concentrations, Batch Digester Area

Evaporator gases were measured at condensate sampling points, which were located in the open air at this mill. Only 7 of 326 samples analyzed (during a 5 day sampling period) contained hydrogen sulfide above the measurable detection limit of 0.001 ppm; the highest concentration of H_2S was 0.01 ppm. Sulfur dioxide generally occurred in trace amounts or undetectable levels. Only 10 readings over 0.1 ppm of methyl mercaptan were recorded with the maximum of 0.3 ppm. Approximately 20 samples contained 0.005 - 0.05 ppm of dimethyl sulfide; 2 samples contained 0.25 and 0.4 ppm; the remaining samples had levels below the detection limit of 0.004 ppm.

Bleach plant gas samples contained no detectable concentrations of chlorine dioxide. Ambient chlorine concentrations, however, usually occurred between 0.2 and 0.4 ppm in and near the bleach plant (Table 56). However, this range was exceeded in a small room housing a pump for hypochloride solution and in the neighborhood of the chlorination stage washer, were 5 samples had concentrations approaching 1 ppm; lastly, in an area near the chlorination-stage filtrate recycle pump concentrations ranged from 2 to 4 ppm. Sulfur dioxide (used as an antichlor) was detected by nose and lungs on occasion in the bleach plant, but no measurable concentrations were detected.

The most significant findings of this study were that dimethyl sulfide was present at higher concentrations than other sulfur containing gases at all locations sampled and that hydrogen sulfide concentrations were very low. Most of the attention given to possible health hazards of sulfur containing gases in the pulp and paper industry has been directed at hydrogen sulfide and, in recent times methyl mercaptan. The results of this study indicated that potential short and long term affects of exposure to dimethyl sulfide may be of higher priority than concerns over hydrogen sulfide. At present, very little is known of the significance to health of dimethyl sulfide. If subsequent studies show that this gas is commonly the most abundant of the sulfur containing gases in kraft mills, animal testing may be required to determine possible adverse symptoms of long term exposure.

Chlorine concentrations were above the comfort level in at least 1 location at the mill. Until additional studies are performed to assess this situation at other mills, high chlorine concentrations should be viewed as a local industrial hygiene matter rather than an indication of an industry wide problem. The absence of detectable concentrations of chlorine dioxide was believed to reflect actual conditions. No odor of chlorine dioxide was detected even inside the D_1 or D_2-stage washer hoods.

Turpentine concentrations in the batch digester area were found to be low, as expected, since the wood species pulped, western hemlock and western red cedar, have a low turpene content.

The results of this study clearly demonstrated the value of a sensitive and selective procedure for measuring sulfur containing gases. Considerably more information on fluctuations in the concentrations of individual gases was obtained by gas chromatography than in routine personal monitoring where gas badges or absorption tubes had been used. The investigators performing this study stated that knowledge of peak concentrations of gases is more useful than time weighted average values in determining health related risks and that follow-up studies will be performed to relate analysis results to process and equipment operating variables at other bleached kraft mills in British Columbia.

The National Occupational Hazard Survey

In the 1972-1974 period, NIOSH conducted the National Occupational Hazard Survey (NOHS), during which approximately 850 chemical and related material agents were identified at integrated pulp and paper mills, paperboard mills, and building paper and board mills (3). During the NOHS walk through, approximately 4,950 of the 5,700 workers observed were in pulp and paper mill occupations directly related to production or manufacturing operations; the remaining workers were determined to be in nonproduction or miscellaneous occupations. Observations recorded during the walk through survey included documentation of worker-identified exposures to chemicals and related material agents, including generic substances and trade name products containing ingredients that could be confirmed only by information supplied by manufacturers (i.e., ink, undefined dyes, waterless hand cleaner, etc.). These agents, which were ranked on the basis of the percent of production workers exposed, are presented in Table 57. The percent of the worker group exposed was determined by dividing the number of persons exposed to each specific agent by the total number of production workers observed in the survey.

Of the approximately 850 agents observed, 15 were identified as carcinogens according to OSHA criteria for Class I or II carcinogens (4). Five percent or less of the production worker group were exposed to these

Table 57 NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTSIN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Waterless Hand Cleaner	30.9	Naphthenic Base Oil	5.7
Water	25.9	Isopropyl Alcohol	5.6
Undefined Chemicals	24.3	Methanol	5.6
Glue-Other	16.1	Hydrogen Chloride	5.5
Products of Combustion-Propane	14.8	Dichloromethane	5.4
		Acetylene	5.3
Paper	12.7	Carbon Arc Lamp Gases	5.3
Mineral Oil	12.2	Sodium Sulfate	5.2
Starch	11.7	Calcium Carbonate	5.2
Solvents, Undefined	11.2	Oleic Acid	5.2
Oil, Lube	11.1	Silicones	5.1
Sodium Carbonate	10.4	Cleaning Compounds	5.1
Defoamer Agents	9.6	Grease	5.1
Propylene Glycol	9.5	Asbestos	5.0
Oil, Fuel No. 1	9.2	Ethyl Acetate	4.8
Grinding Wheel Dust	9.2	Ammonia	4.8
Asphalt	8.5	Oil, Cutting	4.8
Fatty Acids	8.3	Cellulose, Nitrate	4.7
Sodium Chloride	8.2	Mold Release	4.7
Dyes, Undefined	8.1	Bright Stock	4.6
Waxes	8.0	Welding Gases, GAS	4.6
Petroleum Spirits	7.8	Butanone, 2-	4.4
Aluminum Sulfate	7.7	Neutral Oil	4.4
Ultraviolet Radiation	7.4	Aluminum Oxide	4.3
Dichlorodifluoromethane	7.3	Dextrin	4.2
Oil, Penetrating	7.2	Carbon	4.1
Titanium Oxide	7.2	Descumming Agent	4.1
Ethyl Alcohol	7.0	Rosin	4.1
Ink	6.9	Coating	4.1
Sodium Hydroxide	6.8	Polyethylene Glycol Mond (Octylphenyl) Ether	4.1
Products of Combustion-Gasoline (Leaded)	6.8		
Additives, Undefined	6.7	C.I. 74160-Pigment Blue 15	4.0
Wood Pulp Solution	6.7		
Lubricants	6.7	Acetic Acid	3.9
Silica, Amorphous Fused	6.5	Paraffin	3.9
Steel, Oxides of	6.3	Adhesives	3.9
Polyethylene	6.1	Trichloroethane, 1,1,1-	3.9
Infrared Radiation	6.1	Sulfuric Acid	3.9
Toluene	6.0	Alcohols, Undefined	3.9
Woods	5.7	Absorbents	3.8

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Stearic Acid	3.8	Dicyandiamide	2.9
Petroleum Oil	3.8	Acrylic Resins	2.9
Glycerol	3.8	Diethylene Glycol Monoethyl Ether	2.9
Clays	3.8	C.I. 40000-Direct Yellow 11	2.9
Cellulose	3.7	C.I. 45160:1-Pigment Red 81	2.8
Chromic Acid, Lead (2+) Salt (1:1)	3.6	Phosphoric Acid	2.8
Oil, Motor	3.6	Rubber, Chloroprene	2.8
Sizing Compounds	3.6	Polymers, Organic	2.8
Urea	3.6	Trichlorofluoromethane	2.7
Ethoxyethanol, 2-	3.5	C.I. 74180-Direct Blue 86	2.7
C.I. 52015-Basic Blue 9	3.5	Diethanolamine	2.7
Polyethylene Glycol Ether	3.5	Phenol, Polymer With Formaldehyde	2.7
C.I. 77266-Pigment Black 7	3.4	C.I. 29200-Direct Red 72	2.7
Formaldehyde	3.3	C.I. 24401-Direct Blue 218	2.7
Surfactants	3.3	Shellac	2.7
Alkanes	3.3	Polyvinyl Acetate	2.7
C.I. 23850-Direct Blue 14	3.3	Reagents	2.7
Ethylhexyl) Phthalate, Bis(2-	3.3	Products of Rosin Core Solder	2.7
Propane	3.3	Sealants	2.6
Calcium Hydroxide	3.2	Lead Sulfate	2.6
Sodium Polyacrylate	3.2	Dye Solvent	2.6
Sodium Hypochlorite	3.2	Microcrystalline Wax	2.6
Coagulants	3.2	Sodium Aluminate	2.6
Bleaching Agents	3.1	Dye Stuff	2.5
Triazine-Sulfonamide Resin	3.1	Dimethyl Sulfate	2.5
Lanolin	3.1	C.I. 42595:2-Pigment Blue 1	2.5
Talc	3.1	Surfactant	2.5
Dimethicone	3.0	Isopropyl Acetate	2.5
Amines	3.0	Acetone	2.5
C.I. 77891-Pigment White 6	3.0	Decomposition Products-Flux	2.4
Aluminum Hydroxide (AL(OH)3)	3.0	Aminoethylethanol Amine	2.4
Latex	3.0		

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
C.I. 29000-Direct Yellow 44	2.4	Polyvinyl Alcohol	2.0
C.I. 27680-Direct Red 16	2.4	Oil, Linseed	1.9
Polyethylene Glycol P-Nonylphenyl Ether	2.4	C.I. 21100-Pigment Yellow 13	1.9
C.I. 12355-Pigment Red 23	2.4	Graphite	1.9
C.I. 77600-Pigment Yellow 34	2.4	Ethane, 1,1,2-Trichloro-1,2,2-Trifluoro-	1.9
Propanol, 1-	2.4	Tall Oil	1.9
Maleic Modified Penta Ester of Resin	2.3	Maleic Rosin	1.9
C.I. 45160-Basic Red 1	2.3	Acetic Acid Ethenyl Ester, Polymer With Chloroethene	1.9
Diethylaminoethanol	2.3	Ethylene Glycol	1.9
C.I. 15630-Pigment Red 49	2.3	Ammonium Hydroxide	1.9
Flux	2.3	Methyl-2-Pentanone, 4-	1.9
Lactol Spirits	2.3	C.I. 45175-Basic Violet 11	1.9
Gasoline	2.3	C.I. 74260-Pigment Green 7	1.8
Polyamide Resins	2.2	Castor Oil	1.8
Xylene	2.2	Calcium Stearate	1.8
Hydroxyethyl Starch	2.2	Propylene Glycol Methyl Ether	1.8
Heptane	2.2	C.I. 15585-Pigment Red 53	1.8
C.I. 77605-Pigment Red 104	2.2	C.I. 15850-Pigment Red 57	1.8
Polyamide Resin	2.2	Disinfectants	1.8
Wetting Agents	2.1	Propyl Acetate	1.8
Sodium Borate	2.1	Aluminum Phosphate	1.8
Sodium Gluconate	2.1	Ethylcellulose	1.8
Copper (II) Sulfate (1:1)	2.1	Lead Fluoride	1.8
Chloroethane	2.1	Methyl Methacrylate Polymer	1.8
Maleic Resin	2.1	Formaldehyde-Cyclic Ureide-Sulfonamide Resin	1.8
C.I. 77510-Pigment Blue 27; C.I. 77520-Pigment Blue 27	2.1	Styrenated Alkyd Resin	1.8
Styrenated Acrylic Resin	2.0	Triazine-Formaldehyde	1.8
Sodium Pyrophosphate, Tetra	2.0	Caustic Cleaners	1.8

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
C.I. 45170-Basic Violet 10	1.7	Ethyl Ether	1.5
		Menthol	1.5
Epoxidized Soybean Oil	1.7	Fabric Finisher	1.5
Cement-Portland	1.7	Calcium Sulfate	1.5
Decomposition Products-Polymers, Polyethylene	1.7	Inorganic Lead Compounds	1.5
		Degreaser	1.5
Diethyl Phthalate	1.7	Copper	1.5
Barium Sulfate	1.7	C.I. 11270-Basic Orange 2	1.5
Sucrose	1.7		
Styrene-Allyl Alcohol Copolymer	1.7	Sodium Nitrate	1.5
		Glue-Gum	1.4
Cement-Glue	1.6	Tall Oil Fatty Acid	1.4
Diethylene Glycol Monobutyl Ether	1.6	C.I. 41000-Basic Yellow 2	1.4
Oil, Coconut	1.6	Calcium Oxide	1.4
Tallow Fatty Acid	1.6	Tars	1.4
Naphthenic Neutral Oil	1.6	Ethylene Oxide	1.4
Butyl Acetate	1.6	Sulfamic Acid	1.4
Maleic Anhydride	1.6	Glue-Animal	1.3
Ester Gums	1.6	C.I. 22610-Direct Blue 6	1.3
C.I. 77007-Pigment Blue 29	1.6		
		C.I. 28160-Direct Red 81	1.3
C.I. 21108-Pigment Yellow 48	1.6		
		C.I. 56200-Solvent Yellow 44	1.3
C.I. Solvent Orange 57	1.6		
C.I. Solvent Yellow 48	1.6	Belt Dressings	1.3
C.I. 12315-Pigment Red 22	1.6	Rust Inhibitors	1.3
		Soap	1.3
C.I. 42040-Basic Green 1	1.6	C.I. 42535:2-Pigment Violet 3	1.3
C.I. 51319-Pigment Violet 23	1.6	C.I. 42600:1-Pigment Blue 14	1.3
Maleic-Modified Pentaerythritol Ester	1.6	Decomposition Products-Resin, Phenolic	1.3
Bentonite	1.6	Ethoxylated Alcohol	1.3
Contact Cleaner-Electrical	1.6	Magnesium Sulfate	1.3
		Calcium Chloride	1.3
Lead Carbonate	1.6	Diisopropylamine	1.2
Butanol	1.6	Sodium Metasilicate	1.2
Ethanol, 2-Butoxy-	1.5	Filler Compounds	1.2

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Lard Oils	1.2	Tetrachloroethylene	0.9
C.I. 21000-Basic Brown 1	1.2	Layout Fluid	0.9
Hexane	1.2	C.I. 12310-Pigment Red 2	0.9
Nitrilotriethanol, 2,2',2"-	1.1	Naphtholic Dye	0.9
Sodium Sulfite	1.1	Lead Oxides	0.9
Aluminum Stearate	1.1	Tin Oxides	0.9
C.I. 30235-Direct Black 38	1.1	C.I. 42510-Basic Violet 14	0.9
C.I. 40001-Direct Yellow 6	1.1	C.I. 21010-Basic Brown 4	0.9
Phthalic Acid, Dibutyl Ester	1.1	Zinc Chloride	0.9
Ink, Printing	1.1	Potassium Iodide	0.9
Iron Oxide, Brown	1.1	Coolants	0.9
Sodium Phosphate, Tri	1.1	Phenolic Resins	0.8
Calcium Rosinate	1.1	Tallow	0.8
C.I. 42000-Basic Green 4	1.0	Blown Asphalt	0.8
C.I. 15575-Acid Orange 8	1.0	Dodecyl Phenol	0.8
C.I. 29155-Direct Orange 29	1.0	Dodecyl Benzene Sulfonic Acid	0.8
Sodium Nitrite	1.0	Detergents	0.8
Silicic Acid, Disodium Salt	1.0	Dipropylene Glycol	0.8
Antimony Trioxide	1.0	Lead Molybdate	0.8
Zinc	1.0	Titanium Sulfate	0.8
Hydroxyethylcellulose	1.0	C.I. 30145-Direct Brown 95	0.8
Silicic Acid, Calcium Salt	0.9	C.I. 30295-Direct Green 6	0.8
Ozone	0.9	C.I. 50240-Basic Red 2	0.8
Hydrogenated Caster Oil	0.9	C.I. 42555-Basic Violet 3	0.8
Naphthenic Oils	0.9	C.I. 21095-Pigment Yellow 14	0.8
Varnish	0.9	C.I. 23790-Direct Blue 25	0.8
Oil, Other	0.9	C.I. 29060-Direct Yellow 34	0.8
Water Softener	0.9	C.I. 42535-Basic Violet 1	0.8
Oil, Hydraulic	0.9		
Pine Oil	0.9		

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
C.I. 22250-Direct Yellow 1	0.8	Citric Acid	0.6
C.I. Direct Blue 262	0.8	Magnesium Carbonate	0.6
Ethylene, Chloro-, Polymer	0.8	Aerosol Cleaner	0.6
Paint Thinner	0.8	Nitric Acid	0.6
Epoxy Resins	0.8	Nitrogen	0.6
Glucose	0.8	Polypropylene	0.6
Carbon Dioxide	0.8	Sweeping Compound	0.6
Benzene	0.8	Hexylene Glycol	0.6
Paste	0.8	Petrolatum	0.6
Pentaerythritol	0.7	Iron	0.6
Magnesium Oxide	0.7	Amides	0.6
Enamel	0.7	Sodium Petroleum Sulfonate	0.6
Emulsifier	0.7	Boiler Water Treatment Chemical	0.6
Potassium Oxides	0.7	Algicide	0.6
Iron Oxide, Red	0.7	Paint	0.6
Tall-Oil Soaps, Potassium	0.7	Potassium Hydroxide	0.6
Zinc Oxide	0.7	Gum Arabic	0.6
Ammonium Chloride	0.7	Alkyd Resins	0.6
Wood Filler-Plastic Wood Type	0.7	Dichlorobenzene, Ortho-	0.6
Propenenitrile, Polymer With 1,3-Butadiene And Ethenylbenzene, 2-	0.7	Erusticator	0.6
Petroleum Distillates 149-232C	0.7	Ethanolamine	0.5
Aliphatic Hydrocarbons 149-232C	0.7	Iron Oxide, Yellow	0.5
Sodium Pentachlorophenate	0.7	Rosin Ester, Fumaric	0.5
Naphthenic Mineral Oil	0.7	Pentaerythritol Resin Ester	0.5
Dimethyldiallyl Ammonia Chloride Homopolymer	0.7	Modified Starch	0.5
Kaolin	0.6	C.I. 42595-Basic Blue 7	0.5
Proteins	0.6	C.I. 74160-Pigment Green 36	0.5
Iron Silicate	0.6	C.I. 77400-Pigment Metal 2	0.5
Ferric Aluminum Silicate	0.6	C.I. 77491-Pigment Brown 7	0.5
		Sulfonamide-Formaldehyde Resin	0.5
		Aliphatic Hydrocarbons 15.5-149C	0.5

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
C.I. 12360-Pigment Red 31	0.5	Ethylene, Trichloro-	0.5
		Resins, Natural	0.5
C.I. 77847-Pigment White 8	0.5	Black Liquor	0.5
		Products of Combustion-Lignin	0.5
Chlorine	0.5		
Lignin	0.5	Styrene	0.5
Cotton	0.5	Potassium Phosphate, Tribasic	0.5
Lithium Hydroxide	0.5		
Phenyl-Alpha-Naphthylamine, N-	0.5	C.I. 50415:1-Solvent Black 7	0.5
Sodium Soap	0.5	Calcium Hypochlorite	0.5
Polylethoxylated Alcohol	0.5	Mica	0.5
Lead Naphthenate	0.5	Waterproofing Agents	0.5
Brass, Oxides of	0.5	Sodium Lignosulfonate	0.4
Sodium Thiosulfate	0.5	Sodium Xylenesulfonate	0.4
Ammonium Phosphate, Dibasic	0.5	Octadecylamine	0.4
		Tallow Oil	0.4
Hexachloroethane	0.5	Drain Opener	0.4
Fumaric Acid	0.5	Coconut Diethanolamide	0.4
Ethylenediaminetetraacetic Acid Tetrasodium Salt	0.5	Ammonium Stearate	0.4
		Steel, Stainless, Oxides of	0.4
Calcium Aluminate	0.5	Lithium Chloride	0.4
Dimethylaminoethanol	0.5	Acrylamide	0.4
Nabam	0.5	Ronnel	0.4
Naphtha	0.5	Sodium Trichlorophenate	0.4
Tall Oil Alkyd Resin	0.5	Sodium Myristyl Polyether Sulfate	0.4
Calcium Ferrite	0.5		
Sodium Tripolyphosphate	0.5	Oxirane, Methyl-, Polymer with Oxirane	0.4
Acetic Acid Ethenyl Ester, Polymer With Ethene	0.5		
		Bis(Dimethylaminomethyl) Cyclohexanone, 2,6-	0.4
Potassium Dichromate(VI)	0.5	Decomposition Products-Oil, General	0.4
Ammonium Phosphates	0.5		
Glue-Epoxy Base	0.5	Biocides	0.4
Isobutane	0.5	Glycolic Acid	0.4
Sodium Abietate	0.5	Terephthalic Acid	0.4
C.I. Direct Yellow 127	0.5	Calcium Lignosulfonate	0.4
C.I. 17755-Acid Red 137	0.5	Polybutene	0.4
Sodium Linear Alkylbenzene Sulfonate	0.5	Chlorinated Paraffin Wax	0.4

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Potassium Rosin Soap	0.4	Sulfurized Lard Oil	0.3
Calcium Soap of Acetic Acid	0.4	Dimethyl Benzyl Ammonium Chloride	0.3
Polyethylene Glycol Dioleate	0.4	Midcontinent Neutral Base Oil, Solvent-Treated	0.3
Tallow, Sodium Salt	0.4	Calcium Soap of Hydrofol Acid	0.3
Sodium Formate	0.4	Acrylic Emulsion Resin	0.3
Decomposition Products-General	0.4	Sulfite Liquor	0.3
Potassium permanganate	0.4	Hydrogenated Tallow Fatty Acid	0.3
Glass Cleaner	0.4	Sodium Hexametaphosphate	0.3
Water Treatment Compounds	0.4	Ammonium Sulfamate	0.3
Inorganic Hypochlorites	0.4	Antimony Dioxide	0.3
Catalysts	0.4	Freons	0.3
Dioxane, 1,4-	0.4	Insecticides	0.3
Naphthalene	0.4	Thinner	0.3
Sulfur	0.4	Inorganic Chromates	0.3
Vanillin	0.4	Alkyldimethylbenzyl-ammonium Chloride	0.3
Cobalt Drier	0.4	Methyl Salicylate	0.3
C.I. 50420-Acid Black 2	0.4	Gluconic Acid	0.3
Propenoic Acid, 2-Methyl-, Homopolymer, Sodium Salt, 2-	0.4	Algin	0.3
Air Freshner	0.4	Methylolacrylamide	0.3
Pipe Joint Sealer	0.4	Nitrotoluene, Ortho-	0.3
Asphalt Volatiles	0.4	Sodium Lauryl Sulfate	0.3
Stoddard Solvent	0.3	Direct Dyes, Undefined	0.3
Sodium Sulfide	0.3	Lead Oleate	0.3
Decomposition Products-Ammonium Chloride	0.3	Seal Oil	0.3
Butyl Stearate	0.3	C.I. 77520-Pigment Green 15	0.3
Phosphoric Acid, Tritolyl Ester	0.3	C.I. Basic Yellow 13	0.3
Di(Tert-Nonyl) Polysulfide	0.3	Lecithin, Hydroxylated	0.3
Phenolic Modified Penta Ester of Resin	0.3	C.I. Basic Green 3	0.3
Sorbitan Fatty Acid Esters	0.3	Diethylenetriamine-Modified Urea-Formaldehyde Resin	0.3

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Borated Dextrin Adhesive Solids	0.3	Tall Oil Soaps	0.2
Dimethyl Ditallow Ammonium Bentonite	0.3	C.I. 16265-Acid Red 187	0.2
Fumaric Acid-Rosin Adduct	0.3	C.I. 19555-Direct Yellow 28	0.2
Iron Oxides	0.3	C.I. 24890-Direct Yellow 4	0.2
Ink Solvent	0.3	C.I. 40006-Direct Yellow 6:1	0.2
Oils, Essential	0.3	Sulfated Sperm Oil	0.2
Carnauba Wax	0.3	C.I. 29156-Direct Orange 102	0.2
Candelilla Wax	0.3	Anisidine Derivatives	0.2
Potassium Coconut Oil Soap	0.3	Sulfonated Naphthalene Formaldehyde Condensate, Sodium Salt	0.2
Soybean Protein	0.3	Stilbene Dye	0.2
Cadmium Oxides	0.3	C.I. 53186-Solubilized Sulfur Black 1	0.2
Products of Combustion-Fuel Oil	0.3	Potassium Ferrocyanide	0.2
Turpentine	0.3	Helium	0.2
Rubbers, Natural	0.3	Iodine	0.2
Aromatic Hydrocarbons, Undefined	0.3	Oil, Fuel No. 2	0.2
Oleyl Amine	0.3	Silver Oxides	0.2
Phthalic Alkyd	0.3	Sulfur Dioxide	0.2
Sulfated Lard Oil	0.3	Chromic Potassium Sulfate, Dodecahydrate	0.2
Aromatic Hydrocarbons 149-232C	0.3	Manganese Hydroxide	0.2
Cellulose, Carboxymethyl Ether	0.3	Inorganic Thiosulfates	0.2
Buffer	0.3	Phthalic Anhydride	0.2
Polypropylene Glycol Ether	0.2	Montmorillonite	0.2
Sodium Silicofluoride	0.2	Cetyl Alcohol	0.2
Cobalt Oxides	0.2	Ammonium Bromide	0.2
Phosphoric Acid Esters	0.2	Butylene Oxide	0.2
Azo Compounds	0.2	Dipropylene Glycol Monomethyl Ether	0.2
Fish Fatty Acid	0.2	Linseed Alkyd	0.2
C.I. 29190-Direct Red 26	0.2	Poly(Oxy(Methylsilylene))	0.2
C.I. 40002-Direct Orange 5	0.2	Oxoalcohols	0.2
Oils, Undefined	0.2	Polyethylene Glycol Tridecyl Ether	0.2

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Ethoxylated Castor Oil	0.2	Acrylic Acid	0.2
Tripropylene Glycol Monomethyl Ether	0.2	Acrylonitrile	0.2
Ethanone, 2-Bromo-1-(4-Hydroxyphenyl)-	0.2	Ethyl Acrylate	0.2
Quartz	0.2	Lead	0.2
Tributyl Phosphate	0.2	Methyl Acetate	0.2
Antimony Oxides	0.2	Nonylphenoxylpolyethoxyethanol Iodine Complex	0.2
Diethylene Glycol	0.2	Aluminum Silicate	0.2
Fountain Solution	0.2	Dipropylene Glycol Dibenzoate	0.2
Natural Gas	0.2	Pyrogallic acid	0.2
Products of Combustion-Diesel	0.2	Ethylhexyl Acrylate, 2-	0.2
Manganese Sulfate	0.2	Polyethoxy Polypropoxy Polyethoxy- Iodine Complex	0.2
Sodium Hydrosulfite	0.2	Latex, Acrylic	0.2
Inorganic Titanium Compounds	0.2	Crotonic Acid	0.2
Linoleic Acid, 9,12-	0.2	Sodium Sesquicarbonate	0.2
Sorbitol	0.2	Pale Oil	0.2
Potassium Bifluoride	0.2	Boiled Linseed Oil	0.2
Ricinoleic Acid	0.2	Methyl Tallowate	0.2
Tri-N-Butylamine	0.2	Latex, Rubber	0.2
Cumene Hydroperoxide	0.2	Chloroethyl Trimethylammonium Chloride, Chloride, 2-	0.2
Potassium Pentaborate	0.2	Polyvinyl Trimethylbenzylammonium Chloride	0.2
Tetraethylene Glycol 2-(2-Ethyl Hexoate)	0.2	Boric Acid	0.2
Polyethyleneimine	0.2	Oxalic Acid	0.2
Polyethyleneglycol Dimethacrylate	0.2	Rubber, Other	0.2
Bisphenol A Fumarate Resin	0.2	Roofing Cement	0.2
Styrene Polymer	0.2	Printing Chemicals	0.2
Potassium Chromate	0.2	Decomposition Products-Polymer, Polypropylene	0.2
Aluminum Oxides	0.2	Potassium Ferricyanide	0.2
Floor Wax	0.2	Thiourea	0.2
Pigments, Undefined	0 2	Glyoxal	0.2
Offset Printing Compound	0.2	Photographic Chemical	0.2
Polish	0.2		
Primer	0.2		

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Phenol	0.2	Cresol, 2,6-Di-Tert-Butyl-, p-	0.1
Potassium Carbonate	0.2	Benzothiazolethiol, 2-	0.1
Propylene Oxide	0.2	C.I. 42750:1-Pigment Blue 19	0.1
Sodium Citrate	0.2	Soybean Oil	0.1
Polyethers	0.2	Tung Oil	0.1
Soya Alkyd Resins	0.2	Linseed Isophthalic Alkyd Resin	0.1
Potassium Nitrate	0.2	Safflower Oil Alkyd	0.1
Bone Meal	0.2	C.I. 77811-Pigment White 27	0.1
Sorbitan Monostearate	0.2	Sericite	0.1
Soya Fatty Acid	0.2	Aliphatic Petroleum Distillates	0.1
Medium Oil Alkyd Resin	0.2	Cobalt Octanoate	0.1
Polyethylene Glycol Monooleate	0.2	Calcium Manganese Octoate	0.1
Cadmium Oxide	0.2	Petroleum Distillates 232-343C	0.1
Medium Oil Soya Alkyd Resin	0.2	C6-C9 Aromatic Hydrocarbons	0.1
Chromic Oxide	0.2	Dimethyl Dioctadecyl Ammonium Bentonite	0.1
Methyl Trimethoxy Silane	0.2	C.I. 27885-Direct Violet 9	0.1
Aminoethylethanolamine-Fatty Acids Condensate	0.2	Phenolphthalein	0.1
Polymethylsiloxane	0.2	Etching Compound	0.1
Barium Chloride	0.2	Bromcresol Green	0.1
Copper Oxides	0.2	Bromothymol Blue	0.1
Fiberglass	0.2	Chlorphenol Red	0.1
Hydrogen Peroxide	0.2	Cresol Purple	0.1
Methane	0.2	Sodium Phosphate, Dibasic	0.1
Sodium Chlorate	0.2	Glue-Rubber Base	0.1
Deoxidizer	0.2	Photographic Developer	0.1
Roll Cleaner, Printing	0.2	Decomposition Products-Cellulose	0.1
Oils, Fuel (General)	0.2	Urea, Polymer With Formaldehyde	0.1
Pumice	0.2		
Metal Elements	0.2		
Epoxides	0.2		
Ionizing Radiation	0.2		
Ethylbenzene	0.1		
Iron Oxide (FE304)	0.1		
Spermaceti	0.1		
Magnesium Aluminum Silicate	0.1		

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Benzoic Acid	0.1	Cyclohexanol	0.1
Chromic Acid	0.1	Diethylenetriamine	0.1
Magnesium Chloride	0.1	Thiadiazine-2-Thione, Tetrahydro-3,5-Dimethyl-, 2h-1,3,5-	0.1
Petroleum Sulfonate	0.1	Hydrazine	0.1
Diglycol Stearate	0.1	Calcium Phosphates	0.1
Butoxyethyl Acetate, 2-	0.1	Ethylenediaminetetraacetic Acid	0.1
Potassium Persulfate	0.1	Magnesium Silicate	0.1
Butylated Hydroxytoluenes	0.1	Stearyl Alcohol	0.1
Polymethacrylate Resin	0.1	Sodium Phosphate, Tri, Chlorinated	0.1
Triethanolamine Oleate	0.1	Azobisformamide	0.1
Sulfonated Oil	0.1	Cresol Red	0.1
Cycloalkanes	0.1	Lithium Grease	0.1
Phosphorus-Containing Organic Compounds	0.1	C.I. 77955-Pigment Yellow 36	0.1
Cellulose EthylHydroxyethyl Ether	0.1	Ethylenediaminetetraacetic Acid, Sodium Salt	0.1
Isophthalic Alkyd Resin	0.1	Glyceryl Monostearate	0.1
Manganese Drier	0.1	Sorbitol Monostearate	0.1
Coconut Acid	0.1	Octanoic Acid, Zinc Salt	0.1
Styrene-Butadiene Resin	0.1	Dibutyltin Diacetate	0.1
Naphthalene Sulfonate	0.1	Sodium Borates	0.1
Dibutyltin Di-2-Ethylhexoate	0.1	Lead Monoxide	0.1
Butylated Urea-Formaldehyde Resin	0.1	Rubbers	0.1
Hexamethylolmelamine	0.1	C.I. 21090-Pigment Yellow 12	0.1
Decomposition Products-Oil, Lube	0.1	Oxidized Petrolatum	0.1
Magnesium	0.1	Formaldehyde-Toluene Sulfonamide Resin	0.1
Sodium Fluoride	0.1	Lead Chromate, Lead Molybdate, Lead Sulfate Complex	0.1
Sodium Dodecylbenzenesulfonate	0.1	Long Oil-Fish Oil Alkyd Resin	0.1
Trimethylamine	0.1	Sodium Soap of Wool Fat	0.1
Sodium Dichromate(VI)	0.1		
Ammonium Phosphate, Monobasic	0.1		
Mineral Grease	0.1		
Rock Wool	0.1		
Binder Abrasive Wheel	0.1		
Polyvinyl Resins	0.1		

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed	Agent Name	Percent of Group Exposed
Medium Linseed Oil Alkyd Resin	0.1	Incrganic Nitrates	0.1
C.I. Direct Blue 80	0.1	Acetic Acid Esters	0.1
C.I. 12335-Pigment Red 8	0.1	Propylaparaben	0.1
C.I. 21120-Pigment Red 38	0.1	Triethylenetetramine	0.1
C.I. 45170:2-Pigment Violet 1	0.1	Guar Gum	0.1
C.I. 61100-Disperse Violet 1	0.1	Lithium Stearate	0.1
Alkylphenoxypoly (Ethyleneoxy)Ethanol	0.1	Oils, Petroleum-Derived	0.1
Acrylamide-Sodium Acrylate Copolymer	0.1	Green Soap	0.1
Acrylic Copolymers	0.1	Antimony dithiocarbamate	0.1
C.I. 15585:1-Pigment Red 53:1	0.1	C.I. 44045-Basic Blue 26	0.1
Ethanol, 2-Ethoxy-, Acetate	0.1	C.I. 50415-Solvent Black 5	0.1
Polyethylene Glycol Decanoate	0.1	Rosin Maleic Adduct	0.1
Methylenebis(Naphthalene Sulfonate)	0.1	C.I. 14710-Acid Red 4	0.1
Monoazo Dyes, Undefined	0.1	C.I. Direct Yellow 117	0.1
Ink Oil 535	0.1	Hydrogenated Petroleum Base Oil	0.1
Formaldehyde-Amino triazine-Sulfonamide Resin	0.1	C.I. 30110-Direct Brown 1:2	0.1
Carbon Monoxide	0.1	Sulfonated Polystyrene	0.1
Industrial Waste	0.1	Carbon Tetrachloride	0.1
Inorganic Iodides	0.1	Chloroform	0.1
Nitrogen Oxides	0.1	Coal	0.1
Toner	0.1	Oil, Quenching	0.1
Bowl Cleaner	0.1	Sewage, Sanitary	0.1
Products Acid Core Solder	0.1	Whitening Agent	0.1
Silver Nitrate	0.1	Inorganic Sulfur Anion Compounds	0.1
Gallic Acid	0.1	Melamine Formaldehyde	0.1
Antifreeze	0.1	Aluminum Sulfide	0.1
Duplicator Fluid	0.1	Acids, Undefined	0.1
		Brake Fluid	0.1
		Copy Machine Fluid	0.1
		Rubber, Butadiene-Styrene	0.1
		Camphor	0.1
		Cineole	0.1
		Dichlorotetrafluoroethane	0.1
		Isoprene	0.1

(Continued)

Table 57 (Continued) NOHS DATA ON PRODUCTION WORKER EXPOSURES TO CHEMICAL AGENTS IN PULP AND PAPER MILLS (3)

Agent Name	Percent of Group Exposed
Nickel Nitrate	0.1
Phthalic Acid, Benzyl Butyl Ester	0.1
Terpineol, Alpha-	0.1
Manganese Linoleate	0.1
Terpineol, Beta-	0.1
Trimethyl-1, 3-Pentanediol Monoisobutyrate, 2,2,4-	0.1
Tributoxyethyl Phosphate	0.1
Terpinolene	0.1
Gypsum	0.1
Tallow Soap	0.1
Aluminum Paste	0.1
Limonene	0.1
Anethole	0.1
Synthetic Wax	0.1
C.I. 12085-Pigment Red 4	0.1
Sodium Naphthalene Beta-Sulfonateformaldehdye Condensate	0.1
Ethoxybutanol, 2-	0.1
Cobalt Linoleate	0.1
Fenchyl Alcohol	0.1
Isopropylatoluene	0.1
Allylanisole, Para-	0.1
Terpene Alcohols	0.1
Sodium Salt of Carboxylic Acids	0.1
Diisobutylene-Maleic Anhydride Polymer Sodium Salt	0.1
Argon	0.1
Ferric Chloride	0.1
Toluidine, Ortho-	0.1
Methane, Chlorodifluoro-	0.1
Developer	0.1
Glutamic Acid	0.1
Sodium Phthalate	0.1
Morpholine	0.1
Sodium Chromate(VI)	0.1
Zinc Sulfate	0.1
Sodium Bicarbonate (1:1)	0.1
Sodium Bisulfate	0.1
Piperonyl Butoxide	0.1
Benzotriazole, 1,2,3-	0.1
Sodium Sulfosuccinate	0.1
Pyrethrins	0.1
Organic Sulfates	0.1
Isooctyl(2,4-Dichlorophenoxy) Acetate	0.1
Cuprous Chloride	0.1
Alkyl Sulfonate, Linear	0.1
Cyclohexylamine	0.1
Naphtha-High Flash or Heavy	0.1
Monuron Trichloroacetate	0.1
C5-C9 Hydrocarbons	0.1
C5-C9 Aliphatic Hydrocarbons	0.1
Sodium Phosphonate	
Disodium N-(2-Hydroxyethyl)-Iminodiacetate	0.1
Fumaric Acid-Rosin Adduct, Sodium Salt	0.1
Inorganic Manganese Compounds	0.1
Photographic Plate Cleaner	0.1
Salicylic Acid	0.1
Inorganic Silicates	0.1
Correction Fluid	0.1
Curing Agent	0.1
Ajax	0.1
Ammonium Sulfate	0.1
Potassium Phosphate, Dibasic	0.1
Defoliant	0.1
Inorganic Iron Compounds	0.1
Potassium Phosphate, Monobasic	0.1
Plastics, Undefined	0.1

agents in their pure form or as an identified ingredient in a trade name product. These suspected carcinogens and the percent of the survey production work force exposed to these agents are presented in Table 58. In Table 59 each of these carcinogens is listed along with the occupations and industry segment groups in which the exposures were noted. In this table, occupations are noted as either a production/process worker, a non-process worker or a miscellaneous operator. The number of carcinogens reported for each occupation is also noted.

OSHA Sampling Inspections

During the period from July 1972 through April 1980, OSHA monitored the air in pulp and paper mills for the presences of various suspected chemical hazards. Approximately 60 chemical hazards were identified during 1,265 OSHA inspections in which test samples were taken (5). Data from these inspections are presented in Tables 60 through 63 for hazardous substances observed in pulp mills, integrated pulp and paper mills, paperboard mills and building paper and building board mills respectively. Hazardous substances were ranked on the basis of the number of workers affected in sampling tests where OSHA standards were exceeded. Approximately 15,000 workers were considered during these inspections. Asbestos, silica and nuisance dust were hazards that commonly exceeded OSHA standards during these inspections. Gases, such as carbon monoxide, sulfur dioxide, chlorine dioxide, chlorine, hydrogen sulfide and sulfuric acid also exceeded OSHA standards. As indicated in Tables 60 through 63, most of the occurrences of hazardous substances exceeding OSHA standards occurred in integrated pulp and paper mills, followed by paperboard mills and building paper and building board mills.

Data presented in Table 59 support the apparent concentrations of hazards with respect to carcinogens in integrated pulp and paper mills and paperboard mills, where most of the 15 identified carcinogens appearing in the NOHS data are seen. Of the 16 pulp and paper mill occupations associated with asbestos exposure in Table 59, however, only one (asbestos and insulation workers) occurred in an integrated pulp and paper mill, with the predominance of exposures to asbestos occurring in building paper and board mills.

Accidental and Acute Exposures

Fatal or relatively serious accidents requiring medical treatment have been reported by employers required to submit accident and injury reports to OSHA. In Table 64, data taken from the OSHA Management Information System are presented for the period of July 1972 through June 1980 for workers in pulp and paper mills (5,6). According to these data, the highest accident and fatality rates for accidental and acute exposures to chemicals were produced by workers in integrated pulp and paper mills, pulp mills and building paper and board mills in that order; no such occurrences were noted for paperboard mills.

Table 58 CARCINOGENS TO WHICH PRODUCTION WORKERS MAY BE EXPOSED IN PULP AND PAPER MILLS (4)

Agent Name	Percent of Group Exposed
Asbestos	5.0
C.I. 23850-Direct Blue 14	3.3
Dimethyl Sulfate	2.5
C.I. 22610-Direct Blue 6	1.3
C.I. 30235-Direct Black 38	1.1
Tetrachloroethylene	0.9
C.I. 30145-Direct Brown 95	0.8
Benzene	0.8
Hexachloroethane	0.5
Trichloroethylene	0.5
Dioxane, 1,4-	0.4
Thiourea	0.2
Hydrazine	0.1
Carbon Tetrachloride	0.1
Chloroform	0.1

In this investigation, chlorine accounted for the most worker exposures (132 affected workers) followed by carbon monoxide and hydrogen sulfide (14 affected workers each). Relatively few fatalities could be attributed to chemical exposures. Of the 146 workers involved in accidents with chlorine and carbon monoxide, 4 died as a result of exposure. Accidents involving carbon monoxide were due almost entirely to asphyxiations involving industrial vehicles. Five of 14 workers exposed to hydrogen sulfide died in 4 separate accidents.

In Table 65, human factors, attributed to worker behavior, associated with these chemical accidents are presented. It can be seen from this table that the greatest factor contributing to worker exposure to these hazards is "misjudgement of a hazardous situation." The second most frequent contributing factor is "procedures for handling materials not appropriate to task." This category accounts for the most frequent contributing factor to accidents involving exposure to chlorine. Such accidents indicate a need for additional training or the updating of previous training as described later in this section.

In a study performed between 1968 and 1976 to identify high risk areas in the pulp and paper mills, 51 fatalities due to physical as well as chemical hazards were identified (7). The number of occurrences of these fatal accidents within the mills were as follows:

• Pulp and Paper Stock Preparation	15
• Maintenance Department	8
• Paper Machines	7
• Material Handling	5

Table 59 CARCINOGENS OBSERVED FOR SPECIFIC OCCUPATIONS IN PULP AND PAPER MILLS[a]

Occupations:	Carcinogen[b] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Worker Class[c]	Total Number of Agents Per Occupation
Machine Operatives					A		A	A		C	B	B	A B	A B		P	8
Engineering and Science Technicians, N.E.C.		A							A		B	B	B	B	A	P	7
Plumbers and Pipe Fitters	B			A							B	B	B	B		P	6
Checkers, Examiners, and Inspectors; Manufacturing			A		A			A		C				A	A C	P	6
Not Specified Laborers										C	B	B	B	B	B	P	6
Miscellaneous, Unspecified Operatives					A					C	B	B	B	B A		P	6
Chemists							A	A	A					A		N	4
Mixing Operatives										C	A		A			P	3
Research Workers, Not Specified		A	A												A	N	3
Electricians	B						A									P	2
Foremen, N.E.C.								A	A							P	2
Millwrights	B						A									P	2
Stationary Engineers							A								B	P	2
Janitors and Sextons							A			C						P	2
Engineers, N.E.C.		A													A	M	2
Heavy Equipment Mechanics, Incl. Diesel								A							B	M	2
Cranemen, Derrickmen, and Hoistmen										C						P	1
Machinists	B															P	1
Miscellaneous Mechanics and Repairmen								A								P	1
Pressmen and Plate Printers, Printing							B									P	1
Asbestos and Insulation Workers										A						P	1
Cutting Operatives, N.E.C.										C						P	1
Graders and Sorters, Manufacturing										C						P	1
Packers and Wrappers, Except Meat and Produce										C						P	1
Grinding Machine Operatives										C						P	1
Sawyers										C						P	1
Stationary Firemen						A										P	1
Welders and Flame-Cutters	B															P	1
Winding Operatives, N.E.C.										C						P	1
Fork Lift and Tow Motor Operatives										C						P	1
Freight and Material Handlers										C						P	1
Registered Nurses															A	N	1
Duplicating Machine Operators							A									N	1
Secretaries, N.E.C.							A C									N	1
Stenographers							A									N	1
Compositors and Typesetters							A									N	1

a) Taken from NOHS data base for A (Integrated Pulp and Paper Mills), B (Paperboard Mills), and C (Building Paper and Board Mills)

b) Carcinogens are listed as follows:

1 Hexachloroethane	8 Trichloroethylene
2 Carbon Tetrachloride	9 Thiourea
3 Chloroform	10 Asbestos
4 1,4-Dioxane	11 C.I. 30235-Direct Black 38
5 Dimethyl Sulfate	12 C.I. 30145-Direct Brown 95
6 Hydrazine	13 C.I. 22610-Direct Blue 6
7 Tetrachloroethylene	14 C.I. 23850-Direct Blue 14
	15 Benzene

c) P = Production/Process Worker; N = Nonprocess Worker; M = Miscellaneous Worker.

Table 60 OSHA TESTS FOR HAZARDOUS SUBSTANCES IN PULP MILLS

Agent	Total No. of Samples	Total No. of Workers Affected	No. of Samples Exceeding OSHA Standard	No. of Workers Where Samples Exceed OSHA Standard
DUSTS				
Asbestos	2	55		
Nuisance	5	41		
Wood	1	1		
CHEMICALS				
Calcium Oxide	1	1		
Carbon Dioxide	1	30		
Carbon Monoxide	3	56		
Chlorine	10	204	1	3
Chromium	1	1		
Copper	1	3		
Ethyl Mercaptan	1	1		
Formaldehyde	1	3		
Hydrogen Sulfide	3	14		
Iron Oxide	2	4		
Manganese	2	4		
Mercury	1	18		
Methyl Mercaptan	1	1		
Nickel	1	1		
Nitric Oxide	1	3		
Sulfur Dioxide	5	9	2	2
Turpentine	1	1		
Xylene	1	3		
Total	45	454	3	5

• Liquor Tank Rupture	5
• Industrial Vehicles	4
• Recovery Boilers	3
• Wood Yard	2
• Other	2

Of the 15 fatalities occurring in stock preparation areas, 10 fatalities were due to workers being overcome by hydrogen sulfide and sulfur dioxide fumes from the digester or during vessel entry. Although the use of proper breathing equipment during vessel entry could have prevented some of these fatalities, emissions of toxic fumes without warning was responsible for some deaths. The failure to follow proper work procedures was a major cause of other fatalities in stock preparation areas and in maintenance departments. Non-chemical related fatalities in this investigation included falls from ladders and high elevations, electrocutions, and being caught in paper machines and material handling equipment.

Table 61 OSHA TESTS FOR HAZARDOUS SUBSTANCES IN INTEGRATED PULP AND PAPER MILLS

Agent	Total No. of Samples	Total No. of Workers Affected	No. of Samples Exceeding OSHA Standard	No. of Workers Where Samples Exceed OSHA Standard
DUSTS				
Asbestos	24	497	3	24
Cotton	1	1	1	1
Nuisance; Other	58	349	2	2
Silica	26	109	7	20
Wood	10	173		
CHEMICALS				
Acetone	2	11	1	1
Acrolein	1	1		
Acrylonitrile	4	17	1	5
Ammonia	13	1062	1	5
Antimony	2	3	1	2
Benzene	3	10		
Butyl Alcohol	1	4		
Cadmium	1	1		
Calcium Carbonate	1	5		
Calcium Oxide	10	36	1	4
Carbon Monoxide	31	423	1	3
Chlorine	47	3522		
Chlorine Dioxide	6	65		
Chloroform	1	22		
Chromium	5	9		
Coal Tar	2	13	1	12
Copper	1	1		
Ethyl Acetate	3	6		
Ethyl Alcohol	1	3		
Ethyl Cellosolve	3	6		
Ethyl Mercaptan	1	2		
Formaldehyde	8	81		
Hydrogen Chloride	1	9		
Hydrogen Sulfide	23	313	2	11
Iron Oxide	3	4		
Isopropyl Alcohol	2	16		
Lead	9	13	1	1
Manganese	1	2		
Mercury	2	6		

Table 61 (Continued) OSHA TESTS FOR HAZARDOUS SUBSTANCES IN INTEGRATED PULP AND PAPER MILLS

Agent	Total No. of Samples	Total No. of Workers Affected	No. of Samples Exceeding OSHA Standard	No. of Workers Where Samples Exceed OSHA Standard
CHEMICALS (Continued)				
Methyl Cellosolve	1	22		
Methyl Ethyl Ketone	6	48	1	1
Methyl Isobutyl Ketone	4	55		
Methyl Mercaptan	3	105	1	3
Methyl Chloroform	3	11		
Methylene Chloride	1	22		
Molybdenum	1	2		
Nickel	3	4		
Ozone	5	11		
Phosphoric Acid	3	12		
Sodium Hydroxide	1	2		
Styrene Monomer	2	4		
Sulfur Dioxide	21	206	4	25
Sulfuric Acid	4	7		
Tin (Inorganic)	1	1		
Tin (Organic)	1	1		
Toluene	10	95	1	1
Toluene Diisocyanate	1	5		
Vanadium	1	2		
Vinyl Chloride	4	19		
Xylene	7	16	1	1
Zinc Oxide	1	2		
Other Chemicals	7	23		
Total	398	7470	31	122

EFFECTS OF EXPOSURE

In this section, expanded discussions of the occupational health effects of specific agents of significance are presented. Many of these agents may be considered potential hazards because of their known toxic effects and the existance of Federal standards limiting work place exposure. Other agents are included because of their wide spread use or occurrence in pulp and paper industry operations resulting in actual or anticipated worker exposure. Some of these agents may not produce specific toxic effects but may be considered potentially hazardous due to their ability to produce allergic reactions or due to their possible presence in the work place as respirable dusts.

Table 62 OSHA TESTS FOR HAZARDOUS SUBSTANCES IN PAPERBOARD MILLS

Agent	Total No. of Samples	Total No. of Workers Affected	No. of Samples Exceeding OSHA Standard	No. of Workers Where Samples Exceed OSHA Standard
DUSTS				
Silica	3	27		
Asbestos	1	40		
Nuisance; Other	3	13		
CHEMICALS				
Ammonia	1	4		
Calcium Oxide	1	7		
Carbon Monoxide	19	189	1	80
Chlorine	5	52	1	12
Chlorine Dioxide	2	18	2	18
Ethyl Acetate	2	8		
Formaldehyde	1	4		
Hexane	1	2		
Hydrogen Sulfide	8	46		
Isopropyl Acetate	1	2		
Isopropyl Alcohol	1	2		
Methyl Chloroform	1	6		
Methyl Ethyl Ketone	1	2		
N-Propyl Acetate	1	2		
Sodium Hydroxide	4	52		
Sulfur Dioxide	3	32	1	12
Sulfuric Acid	4	58	2	12
Toluene	1	2		
Toluene Diisocyanate	2	8		
Total	66	576	7	134

The following discussions on biological effects, which are intended to expound data presented for each subject agent presented in the Chemical Profiles (Appendix A), have been summarized from relevant NIOSH criteria documents and other research literature, including the following standard references on toxicology: Chemical Hazards of the Work Place (8), Clinical Toxicology of Commercial Products (9), Handbook of Industrial Toxicology (10), The Merck Index (11), Casarett and Doull's Toxicology (12), and Dangerous Properties of Industrial Materials (13).

Table 63 OSHA TESTS FOR HAZARDOUS SUBSTANCES IN BUILDING PAPER AND BUILDING BOARD MILLS

Agent	Total No. of Samples	Total No. of Workers Affected	No. of Samples Exceeding OSHA Standard	No. of Workers Where Samples Exceed OSHA Standard
DUSTS				
Asbestos	19	470	4	14
Nuisance; Other	18	240	4	18
Silica	3	36	1	2
Talc	1	12		
Wood	5	26	1	7
CHEMICALS				
Acrylamide	1	6		
Acrylonitrile	1	4		
Benzene	2	9		
Benzopyrene	1	1		
Butyl Cellosolve	1	1		
Carbon Monoxide	6	211		
Chromium	1	2		
Coal Tar	3	11		
Formaldehyde	1	100		
Hexane	1	6		
Isobutyl Acetate	1	3		
Lead	1	1		
Mercaptobenzene	1	1		
Methyl Ethyl Ketone	4	18	1	6
Nickel	1	2		
Nitric Oxide	1	1		
Ozone	1	1		
Pentachlorophenol	1	6		
Methyl Chloroform	1	6		
N-Propyl Acetate	1	2		
Other Chemicals	2	5		
Total	89	1220	11	47

Table 66 presents a list of specific chemicals and material groups for which expanded discussions of occupational effects are presented. Each agent in Table 66 is listed along with its CAS (Chemical Abstracts Service) registry number, OSHA hazardous substance code, and NOHS hazard code.

Table 64 ACCIDENTS AND FATALITIES DUE TO CHEMICAL HAZARDS IN PULP AND PAPER MILLS

Hazard	Type of Date	Pulp Mills	Paper Mills	Building Paper/Board Mills	Total
Chlorine	Accident Events*	5	10		15
	Workers Affected	48	84		132
	Fatalities	2	0		2
Carbon Monoxide	Accident Events*	1	1		2
	Workers Affected	12	2		14
	Fatalities	0	2		2
Hydrogen Sulfide	Accident Events*	2	2		4
	Employees Affected	6	8		14
	Fatalities	1	4		5
Sodium Hydroxide	Accident Events*	1	1		2
	Workers Affected	1	1		2
	Fatalities	0	1		1
Unidentified Chemicals	Accident Events*			1	1
	Workers Affected			2	2
	Fatalities			2	2
Total	Accident Events*	9	14	1	24
Total	Workers Affected	67	95	2	164
Total	Fatalities	3	7	2	12

*Separate events in the same or different plants (usually different plants)

Acetic Acid

Acetic acid vapor is a severe irritant of the eyes, mucous membranes and skin. Exposure to 50 ppm or more is intolerable to most persons and results in intense lacrimation and irritations of the eyes, nose, and throat, with pharyngeal edema and chronic bronchitis. Unacclimatised humans experience extreme eye and nasal irritation at concentrations in excess of 25 ppm; conjunctivitis from concentrations below 10 ppm have been reported (8).

In a study of five industrial workers exposed to peak concentrations of 80 to 200 ppm for 7 to 12 years, the principal findings were blackening and hyperkeratosis of the skin of the hands, conjunctivitis (with no corneal damage), bronchitis and pharyngitis and erosion of exposed teeth (incisors and canines) (14). Pure acetic acid has been reported to cause permanent corneal opacification. An acetic acid solution of 4 to 10% (vinegar) in the eye causes immediate pain and conjunctival hyperemia with occasional injury to the corneal epithelium (8).

Although ingestion is unlikely to occur in industrial use, as little as 1 ml of pure acetic acid has resulted in perforation of the esophagus (8).

Table 65 HUMAN FACTORS AND WORKERS AFFECTED FOR ACCIDENTS ASSOCIATED WITH CHEMICAL HAZARDS

	Number of Workers Affected					
Contributing Human Factor	Chlorine	Carbon Monoxide	Hydrogen Sulfide	Sodium Hydroxide	Unidentified Chemical	Total
Misjudgement of hazardous situation	35	2	6	2	2	47
Personal protective equipment not used	2					2
Malfunction of procedure for securing operation or warning of hazardous situation	5		7			12
Equipment in use not appropriate to operation or process	12					12
Malfunction of perception system with respect to task environment	8					8
Operational position not appropriate to task		12				12
Procedure for handling materials not appropriate to task	38					38
Defective equipment in use	9					9
Other	23		1			24
Total Workers Affected	132	14	14	2	2	164

Acrylamide

A total of 45 cases of intoxication from acrylamide have been reported in humans (15). Symptoms of excessive exposure in industrial workers have included drowsiness, fatigue, tingling of the fingers, stumbling and propulsive gait (14). In six well documented cases of intoxication among chemical workers exposed to acrylamide dust over a period of 4 to 12 weeks, symptoms included of numbness and paresthesia of the limbs, muscular weakness, absent deep tendon reflexes, severe ataxia and fatigue and lethargy (8). Increased sweating and erythema of the hands were characteristic of most cases, including peeling skin of the palms of some workers. Recovery was slow; on the more severely affected of the workers, recovery was still incomplete after several months. In six cases, excessive skin contact with acrylamide dust had occurred, with dissolution of the dust in sweat probably contributing to unusual skin absorption. Intoxication was not observed where extra care had been taken to avoid skin contact.

Aluminum Sulfate

Aluminum sulfate is generally thought to exhibit low toxicity. However, ingestion of 30 grams on two occasions by an adult human has resulted in death (9). This lethal effect was attributed to the corrosive action of sulfuric acid that was formed from hydrolysis of the salt. Other human effects resulting from ingestion of concentrated solutions include gasteroenteritis, necrosis of gum tissue, incoordination, clonic muscular contractions, and evidence of nephritis.

Table 66 REGISTRY INFORMATION FOR AGENTS ASSOCIATED WITH PULP AND PAPER MILL OPERATIONS

Hazard	CAS #	OSHA #*	NOHS #**
Acetic Acid	64-19-7	0020	01568
Acrylamide	79-06-1	0115	03540
Aluminum Sulfate (Alum)	10043-01-3	0160	04620
Ammonia	7664-41-7	0170	05250
Asphalt			
Benzene	71-43-2		09070
Calcium Oxide (Lime)	1305-78-8	0520	15755
Carbon Black	7440-44-0	0527	80245
Carbon Monoxide	630-08-0	0560	17460
Carbon Tetrachloride	56-23-5		17490
Chlorine	7782-50-5	0640	18040
Chlorine Dioxide	10049-04-4	0614	18045
Chloroform	67-66-3		18500
Dimethyl Disulfide	624-92-0		
Dimethyl Sulfate	77-78-1		26880
Dimethyl Sulfide	75-18-3		84745
Dimethyl Sulfoxide	67-68-5		80564
Dioxane	123-91-1		25145
Dust, Fibrogenic			
Asbestos	1332-21-4	9020	90310
Silica	60676-86-0	9010	M4331
Talc	14807-96-6	9030	71055
Dyes/Pigments			
Formaldehyde	50-00-0	1290	33640
Formic Acid	64-18-6	1310	33720
Hexachloroethane	67-72-1		17385
Hydrazine	302-01-2	1390	38110
Hydrogen Peroxide	7722-84-1	1470	38605
Hydrogen Sulfide	7783-06-4	1480	38620
Kerosene	8008-20-6	1570	
Magnesium Oxide	1309-48-4	1610	80298
Methyl Mercaptan	74-93-1	1643	45850
Polychlorinated Biphenyls			
Aroclor 1242	53469-21-9		
Aroclor 1254	27323-18-8		
Rosin	8050-09-7		80164
Sodium Hydroxide	1310-73-2	2260	69070
Sodium Hypochlorite	7681-52-9		69090
Sodium Sulfate	7757-82-6		81663
Sulfur	7704-34-9		70845
Sulfur Dioxide	7446-09-5	2290	70860
Sulfuric Acid	7664-93-9	2310	70870
Tetrachloroethylene	127-18-4		54790
Titanium Dioxide	13463-67-7	2440	A1358
Thiourea	62-56-6		82272
Trichloroethylene	79-01-6		73790
Turpentine	8006-64-2	2540	74990
Wood Dust		9210	M1327
Zinc Oxide	1314-13-2	2610	77190

*OSHA Hazardous Substance Code
**NOHS Hazard Code

Ammonia

Ammonia is a severe irritant of the eyes, respiratory tract and skin. Exposure to and inhalation of concentrations of 2500 to 6500 ppm cause severe corneal irritation, dyspnea, bronchospasms, chest pain, and pulmonary edema, which may be fatal. Consequences of exposure include bronchitis or pneumonia, with some residual reduction of pulmonary function having been recorded (16).

In a human experimental study where 10 subjects were exposed to various vapor concentrations for 5 minutes, 134 ppm caused irritation of the eyes, nose, and throat in most, with one person complaining of chest irritation. At 72 ppm, several subjects reported the same symptoms. At 50 ppm, two subjects reported nasal dryness; at 32 ppm only one reported nasal dryness (17). In a survey of 8 workers in a blue print shop, ammonia concentrations of 4 to 29 ppm caused minimal to moderate eye irritation with no respiratory irritation reported (8). A phenomenon frequently observed in industrial workers is an acquired adaptation or tolerance to usually irritating concentrations of ammonia. No data are available on concentrations that are irritating to workers who are regularly exposed to ammonia and who presumably have a higher irritation threshold (8).

Liquid anhydrous ammonia in contact with the eyes may cause serious eye injury or blindness. On the skin, this form of ammonia may cause first and second degree burns, which are often severe and, if extensive, may be fatal. Vapor concentrations of 10,000 ppm are mildly irritating to the moist skin, while 30,000 ppm or greater cause a stinging sensation and may produce skin burns and vesiculation (8).

Asphalt (Petroleum) Fume

Asphalt fume contains a large number of organic chemicals. Many of the chemicals are present only in trace amounts and may even be undetectable by standard methods of analysis. Asphalt fume contains condensed particles composed of long chain, complex, high-boiling hydrocarbons. It also contains hydrocarbons that are vapors at room temperature. These vapors may include the aliphatic hydrocarbons C-8 through C-16 and certain aromatic hydrocarbons such as toluene or benzene. Toluene can cause irritation of the eyes, respiratory tract, and skin. Acute exposure to toluene results in central nervous system depression. Heating of asphalt may generate into the atmosphere such polynuclear aromatic (PNA) compounds as anthracene, chrysene, pyrene, fluoranthene, and benz(a)pyrene (BAP). Benz(a)pyrene is considered as a carcinogen, although it is not currently a regulated carcinogen. The other PNA's are on the NIOSH suspected carcinogen list. In any given batch of asphalt, there may or may not be BAP present in trace amounts. Even though BAP is not a regulated carcinogen and does not have an established environmental limit, it can be a potential health hazard in asphalt shingle manufacturing plants since the amount of BAP (if any) in each batch of asphalt is so variable. In general, the components of asphalt fume present in high enough quantities may produce narcotic symptoms and eye, nose, and throat irritation (18).

Benzene

Benzene is an agent identified during the NOHS walk-through as a carcinogen to which 0.8% of the pulp and paper mill worker group is exposed.

Acute benzene exposure causes central nervous system depression. Chronic expsoure results in depression of the hematopoietic system and is said to be associated with an increased incidence of leukemia.

Brief exposure to concentrations in excess of 3000 ppm is irritating to the eyes and respiratory tract; continued exposure may cause euphoria, nausea, a staggering gait, and coma (8). Inhalation of lower concentrations (250 to 500 ppm) produces vertigo, drowsiness, headache, and nausea (19). Exposures of five to ten minutes to very high concentrations, approximately 20,000 ppm, has been known to be fatal (8).

The most significant toxic effect of benzene exposure is an insidious and often irreversible injury to the bone marrow. Long-term exposures to low concentrations have been observed to have an initial stimulant effect on the bone marrow, followed by aplasia and fatty degeneration. Clinically, an initial increase followed by a decrease in the erythrocytes, leucocytes, or platelets has been observed with progression to aplastic anemia, leukopenia, pancytopenia, and thrombocytopenia (19). Typical symptoms may be light-headedness, headache, nausea, loss of appetite, and abdominal discomfort; with more severe intoxication, there may be weakness, blurring of vision, and dyspnea on exertion. The mucous membranes and skin may appear pale; a hemorrhagic tendancy may result in petechiae, easy bruising, epistaxis, bleeding from the gums, or menorrhagia (20).

Clinical and epidemiologic data suggest a leukemogenic action of benzene in humans, with leukemia tending to be acute and myeloblastic in type, sometimes following aplastic changes in the bone marrow. Benzene may also induce chronic types of leukemia (8). It is important to emphasize, however, that human exposure to benzene often involves comcomitant expsoure to other solvents and that animal experiments have not supported the view that benzene is a leukemogen (8).

One epidemiologic study has indicated a fivefold excess of all leukemias and a tenfold excess of myelomonocytic leukemia among benzene-exposed workers as compared with the total U.S. white male population (21). In other studies, latency periods of up to 15 years following cessation of benzene exposure have been observed in the development of acute leukemia (19).

Among industrial workers exposed to benzene, excessive chromosome aberrations (stable and unstable) in the nuclei of lymphocytes have been reported (8). Tests of phenol levels in urine have been used as an index of benzene exposure; urinary phenol concentrations of 200 mg/liter are indicative of exposure to approximately 25 ppm of benzene in air (8).

Direct contact with the liquid may cause erythema and vesiculation. Prolonged or repeated contact has been associated with the development of a dry, scaly dermatitis or with secondary infections (19).

Calcium Oxide (Lime)

Calcium oxide is caustic to tissue, as it reacts with water to form calcium hydroxide with the evolution of heat. Calcium hydroxide is a major industrial hazard since it may cause dermatitis, bronchitis and pneumonia if inhaled (13,22). Calcium oxide may also react with carbon dioxide in the air to form calcium carbonate. This agent is less toxic than calcium oxide and its presence may decrease the caustic effects of exposure to the oxide (13).

Calcium oxide burns are especially hazardous to the eyes. The oxide reacts with the eyes' moisture and protein, resulting in reaction products that can be difficult to remove by usual irrigation techniques. These products tend to lodge in inaccessible locations and liberation of calcium hydroxide over long periods may occur if the products are not removed promptly (12). Lacrimation, spasmotic blinking, ulceration, and ocular perforation may result from contact with the oxide (22).

Carbon Black

Although an OSHA standard of 3.5 mg/m^3 was developed to protect against carcinogenesis and respiratory effects (23), there are no well demonstrated health hazards to the human from exposure to carbon black. Skin cancer and cancer of the nasal sinus have been associated with carbon dust, however, it is not clear whether such effects are due to carbon particles, coal tar products which adhere to them or a combination of these factors.

Carbon Monoxide

The human health hazards associated with exposure to carbon monoxide (CO) are well known and documented. As stated in the NIOSH publication Occupational Diseases (22), CO combines with hemoglobin to form carboxyhemoglobin which interferes with the oxygen carrying capacity of blood, resulting in a state of tissue hypoxia. The typical signs and symptoms of acute CO poisoning are headache, dizziness, drowsiness, nausea, vomiting, collapse, coma, and death. Initially, the victim is pale; later, the skin and mucous membranes may turn cherry-red. Loss of consciousness occurs at about the 50% carboxyhemoglobin level. The amount of carboxyhemoglobin formed is dependent on the concentration and duration of CO exposure, ambient temperature, and the health and metabolism of the individual. Recovery from acute poisoning usually occurs without sequelae. Exposure of individuals with coronary artery disease to CO concentrations resulting in carboxyhemoglobin levels greater than 5% may produce deleterious effects on the heart, including restricted coronary artery blood flow and decreased myocardial lactate production.

The factors cited above led to a NIOSH recommended 8-hour time-weighted average exposure level of 41 mg/m^3 (24). Although this standard was based in part on CO concentrations that were not expected to increase workers' carboxyhemoglobin levels above 5%, carboxyhemoglobin levels in chronic cigarette smokers are purportedly at or near this level without additional enviromental exposure (24, 25).

The NIOSH criteria document on CO also indicated that there is disagreement about conditions of CO exposure that produce specific biologic effects, especially at concentrations below 117 mg/m^3 (24). In particular, assessment of neurophysiologic effects of CO exposure by analysis of electroencephalograms, visual evoked responses, and conditioned behavioral responses may produce different conclusions.

Carbon Tetrachloride

This solvent was identified during the NOHS walk-through as a carcinogen to which 0.1% of the pulp and paper mill worker group are exposed.

Carbon tetrachloride causes central nervous system depression and severe damage to the liver and kidneys. The majority of fatalities have been the result of renal injury with secondary cardiac failure (26,8). Liver damage occurs more often after ingestion of the liquid than after inhalation of the vapor. Autopsy results have shown renal tubular necrosis.

Fatalities from acute renal damage have occurred after exposure, for 30 minutes to one hour, to concentrations of 1000 to 2000 ppm; occasional sudden deaths may have been cuased by ventricular fibrillation (26,8). Exposure to high concentrations, resulting in symptoms of central nervous system depres sion, including dizziness, vertigo, incoordination, and mental confusion; abdominal pain, nausea, vomiting, and diarrhea are frequent (26,8). Cardiac arrhythmias and convulsions may also occur, as well as polycythemia followed by anemia and hemodiultion. Within a few days of exposure, jaundice may appear and liver injury may progress to toxic necrosis. At the same time, acute nephritis may occur with albumin, red and white blood cells, and casts in the urine. There may also be oliguria, anuria, and increased nitrogen retention resulting in the development of uremia.

There are several reports of adverse effects in workmen who were repeatedly exposed to concentrations between 25 and 30 ppm; nausea, vomiting, dizziness, drowsiness, and headache were frequently noted (26,8). Chronic exposure has caused cases of various abnormalities of the eyes, such as reduced visual field (26). There is also a known synergistic effect from excessive alcohol abuse and exposure to carbon tetrachloride (26,8). Alcohol has been a concomitant factor in many of the human cases of poisoning, especially in cases in which severe liver and kidney damage have occurred.

The liquid splashed in the eye causes pain and minimal injury to the conjunctiva. Prolonged or repeated skin contact with the liquid may result in skin irritation (8).

Chlorine

According to NIOSH, the irritating properties of chlorine make it a serious respiratory hazard, as well as a skin and eye irritant (27). Chronic lung diseases have been reported in persons accidentally exposed to chlorine at high concentrations and during the bleaching of waste paper stock using nonautomated procedures (28). Also, accidental exposures to massive concentrations have, on occasion, been associated with electrocardiographic changes, instances of significant sinus tachycardia, isolated ventricular extra-systoles, and signs of repolarization disturbances of the left ventricle. Historically, various exposure standards have been promulgated in order to minimize chronic changes in the lungs, accelerated aging, and erosion of the teeth.

In Occupational Diseases (22), NIOSH reported that prolonged exposure to low concentrations of chlorine may cause chloracne, and that chlorine in high concentrations acts as an asphyxiant by causing cramps in the muscles of the larynx, swelling of the mucous membranes, nausea, vomiting, anxiety, and fainting. Extensive exposure may result in acute respiratory distress manifested by cough, hemoptysis, chest pain, dyspnea, and cyanosis. In addition, tracheobronchitis, pulmonary edema, and pneumonia may occur.

The National Research Council (29), in a report to EPA, indicated that worker exposures to low (0.02-4.1 mg/m^3) time-weighted-average chlorine concentrations did not produce significant pulmonary changes when compared with a matched control cohort. However, there are individuals, such as heavy smokers and those with cardiovascular problems, who may be particularly susceptible to adverse effects of exposure to chlorine at usually acceptable environmental concentrations.

Chlorine Dioxide

Exposure to chlorine dioxide may cause irritation of the eyes, nose, and throat. Symptoms include coughing, headache, rhinorrhea, conjunctivitis, bronchitis, pulmonary edema, chronic bronchitis, emphysema, and gastrointestinal disturbances (30).

It has been determined that chlorine dioxide along with chlorate and chlorite ions can oxidize hemoglobin to methemoglobin in vivo (31). Since methemoglobin is incapable of combining in reverse with oxygen, exposure to these chemicals result in a decreased oxygen carrying capacity of the blood. An individual exposed to these chemicals could therefore become cyanotic.

Chloroform

This agent was identified during the NOHS walk-through as a carcinogen to which 0.1% of the pulp and paper mill worker group are exposed.

Chloroform is a central nervous system depressant that is toxic to the liver and kidneys. It has been largely abandoned as an anesthetic agent because of the frequency of cardiac arrest during surgery and of delayed death due to hepatic injury (8). An increased incidence of cardiac arrhythmias was demonstrated during surgery in patients anesthitized with chloroform as compared with other anesthetic agents; vapor concentrations were approximately 22,500 ppm (32).

In experimental human exposures, 14,000 to 16,000 ppm caused rapid loss of consciousness in man; 4100 ppm or less caused serious disorientation, while single exposures of 1000 ppm caused dizziness, nausea and after-effects of fatigue and headache (8). Prolonged exposure ranging from 77 ppm to 237 ppm caused lassitude, digestive disturbances, and mental dullness, while 20 to 70 ppm produced milder symptoms (8). Of 68 chemical workers exposed regularly to concentrations of 10 to 200 ppm for one to four years, nearly 25% had hepatomegaly. However, another group exposed repeatedly to about 50 ppm experienced no signs or symptoms (8).

High concentrations of vapor cause conjunctival irritation and blepharospasm. Liquid chloroform splashed in the eye causes immediate burning pain and conjunctival irritation; the corneal epithelium may be injured, but regeneration is prompt; the eye returns to normal in one to three days (8). The liquid has a defatting effect on the skin and may produce chronic irritation with drying and cracking (8).

Dimethyl Disulfide

Although toxicity studies are lacking, dimethyl disulfide is probably highly toxic since alkyline sulfides are similar in action to alkalis (13). These substances cause softening and irritation of the skin and are corrosive and irritating to most tissues because they liberate hydrogen sulfide and free alkali.

Dimethyl Sulfate

Dimethyl sulfate, which is a methylating agent in the manufacture of dyes and pigments, was identified during the NOHS walk-through as a trade name ingredient carcinogen to which 2.5% of pulp and paper mill productions workers are exposed.

Dimethyl sulfate is a severe irritant of the eyes, mucous membranes, and skin; it is carcinogenic in rats.

Several human deaths have occurred from occupational exposures (8). Exposure of humans often produces no immediate effects other than occasional slight eye and nose irritation. After a latent period of up to ten hours or more, however, there is onset of headache and giddiness with intense conjunctival irritation, photophobia, and angioneurotic edema. These symptoms are usually followed by inflammation of the pharyngolaryngeal mucousa, dysphonia, aphonia, dysphagia, productive cough, oppression in the chest, dyspnea, and cyanosis. Vomiting and diarrhea may intervene (8). Dysuria may occur for three to four days; there may be persistence in laryngeal edema for up to two weeks and of photophobia for several months (8). Other effects are delirium, fever, icterus, albuminuria, and hematuria (14).

Contact of the liquid with the eyes or skin will cause very severe burns due to its powerful vesicant action. In one incident of moderate skin contact with the liquid, generalized intoxication occurred even though there was prompt treatment of the skin. During this incident, vapor inhalation occurred for only a few minutes (14).

Dimethyl Sulfide

Dimethyl sulfide (DMS) is a minor metabolite of dimethyl sulfoxide (DMSO) (33). DMS is known to have effects similar to those of sulfur dioxide when heated. It is also known to be a moderate eye irritant. Little else is known of the acute or chronic human health effects of this agent.

Dimethyl Sulfoxide

Although DMSO has been used extensively as an industrial solvent, it has received wide publicity as a potential topical analgesic and anti-inflamatory agent. It has been under intensive pharmacological and clincal study because of its potential theraputic use and as a possible carrier to enhance absorption of other agents (11,34).

This colorless hygroscopic liquid readily penetrates intact skin and other tissues. When applied cutaneously, DMSO is relatively non-toxic and has a probable human oral LD_{50} greater than 15 g/kg (9). The possible systemic toxic effects of DMSO include nausea, vomiting, chills, cramps, and lethargy (9,11).

Dioxane

Dioxane was identified during the NOHS walk-through as a carcinogen to which 0.4% of pulp and paper mill production workers are exposed.

Dioxane is an irritant of the eyes, mucous membranes, and skin. On prolonged exposure, it is toxic to the liver and kidneys. Human volunteers exposed for 15 minutes to 300 ppm reported mild transient irritation of the eyes, nose, and throat (8). Fatal intoxication due to liver necrosis and severe kideny damage has been reported in industrial workers after two months of heavy exposure (levels unmeasured) to dioxane vapor; the onset of poisoning was marked by drowsiness and headache, nausea, vomiting, and irritation of the eyes and respiratory passages (8). In another fatal case, significant damage to the brain as well as to the liver and kidneys occurred upon significant absorption of the liquid through the skin (8).

Prolonged or repeated skin contact may result in drying and cracking due to defatting action. Due to its mild odor, serious or fatal exposures have been experienced without forewarning.

Dust, Fibrogenic

Asbestos, crystalline silica (quartz), talc, and diatomaceous earths have been identified as fibrogenic dusts (35). If these materials are inhaled over a period of time, a tissue reaction occurs in which normal lung tissue is replaced with fiberous tissue. Such occurrences lead to reduced pulmonary function by a reduction in the total amount of lung surface available for gas exchange and/or a reduction in the elasticity of the lung. A consequence is a limitation of the amount of air that can be brought to the gas exchange areas. Thus, the ability of the lungs to oxygenate the blood is reduced. In severe cases, reduced oxygenation impairs work capacity, leading to dyspnea or labored breathing at the slightest effort. Chemical, aetiologic factors of the various forms of dusts that are associated with the promotion of silicosis and pneumoconiosis are identified in Table 67.

Table 67 DUST FORMS INVOLVED IN THE PRODUCTION OF SILICOSIS AND RELATED FORMS OF PNEUMOCONIOSIS

Dust Type	Etiologic Factors	Reaction Site	Type of Response	Designation
Silica (Quartz)	Silica, SiO_2	Lung parenchyma Lymph nodes Hilus	Collagen with some reticular nodes	Silicosis (tuberculosis)
Coal	Coal plus SiO_2 and others	Lung parenchyma Lumph nodes Hilus	Primarily collagen nodules	Anthracosilicosis
Graphite	Finely divided coal plus SiO_2 and others	Lung parenchyma Lymph nodes Hilus	Primarily collagen nodules	Graphite lung
Kaolin	$Al_2(SiO_2)_5(OH)_4$ plus crystalline SiO_2	Lung parenchyma Lymph nodes Hilus	Primarily collagen nodules	Kaolinosis
Diatoms	Amorphous SiO_2	Lung parenchyma	Diffuse fibrosis	Diatom lung (kieselguhr lung)
Talc	$Mg_6(SiO_2)(OH)_4$	Lung parenchyma Lymph nodes	Collagen nodes Granulomata	Pleural sclerosis
Asbestos	Fibrous silicates (Mg, Ca, & others)	Lung parenchyma	Diffuse fibrosis	Asbestosis

Asbestos Dust

Asbestos, an agent identified during the NOHS walk-through as a carcinogen to which 5.0% of pulp and paper mill production workers are exposed, is a generic term for crystalline fibers of the serpentine and amphibole family of minerals. Asbestos fibers less than 3 m in diameter are respirable and can penetrate into the alveoli of the lungs. These fibers, which are generated in many industrial processes, may produce a diffuse, nonmodular fibrosis that spreads along the supporting structures of the lung, leading to distruction of the alveoli and vascular bed. Such a fibrosis causes restrictive impairment, reducing lung volume, vital capacity and residual volume without increasing resistance to flow in the lung. Radiographic changes are small, poorly defined, irregular densities in contrast to those seen in silicosis. There is a growing evidence that most asbestos-related cancers in humans may be the result of the co-carcinogenic effects of asbestos inhalation and cigarette smoking (1).

Silica and Diatomaceous Earths

Kaolin and other diatomaceous earths contain amorphous and crystalline forms of silica. Potential human health hazards of many of these silicates depend on the degree to which these materials are contaminated with crystalline quartz silica. Based on X-ray diffraction studies, diatomaceous earths and other amorphous silica materials are frequently contaminated with crystalline silica (36). Since even small amounts of crystalline silica can produce lung fibrosis (37), it is necessary that the crystalline silica content of amorphous silica additives be known. The recommended exposure levels of crystalline silica are therefore lower than those for amorphous silica.

When exposure to crystalline silica occurs, it may include exposure to fibers containing crystals of quartz, tridymite, or cristobalite. Upon inhalation and pulmonary deposition of these fibers, symptoms include cough, dyspnea, wheezing and repeated non-specific chest illnesses. The resulting silicosis legions are composed of concentrically arranged bundles of collagen found in the lymphatic system and beneath the pleura in the lungs (1-10 mm diameter nodules). Of these crystalline forms, studies have shown that the most fibrogenic form appears to be tridymite, followed by cristobalite and quartz (37).

Although studies of workers in the diatomite industry have revealed no evidence of an association between X-ray changes observed in silicosis and tuberculosis, tuberculosis susceptibility is known to be enhanced by silicosis. The extent to which a silicosis association with tubercular changes is characteristic of other pneumoconioses is uncertain (1).

Talc Dust

Talcosis is a pulmonary fibrosis with non-specific tissue changes. X-ray changes show varying degrees of wide-spread modulation, usually with thickened pleura (35). Impaired ventilatory function and diffusing capacity of the lung are common. Cyanosis and clubbing occur with progression. Not all talcs produce fibrosis. As talc is found naturally in both fibrous and non-fibrous forms, there is disagreement on the degree of pathogenicity of the two forms (1).

Dyes and Pigments

Many toxic effects have been associated with the use of dyes and pigments. The reaction of these substances with body tissues have been related to the occurrence of carcinogenicity, mutagenicity, respiratory dissorders, dermal irritation, allergy, ocular damage, and damage to the liver, kidneys, and other organs including the cardiovascular, skeletal, and reproductive systems (38). Adverse health effects of these materials have been reviewed for the following chemical classes of dyes and pigments used in the pulp and paper industry:

- Azo dyes and pigments (Monoazo, Diazo, Triazo)
- Stilbene dyes
- Diphenylmethane dyes
- Triphenylmethane dyes

Carbon Black, titanium dioxide and zinc oxide, which are not included in the above classification and are not presented in the following discussion, are reviewed separately in this section.

The most frequent adverse affects reported for azo dyes are contact dermatitis and skin reactions such as pruritis and urticaria. The allergic nature of some of these responses have included asthma-like bronchoconstriction upon exposure, as well as cross-sensitivities with other substances (39).

Table 57 includes many dye and pigment substances which were identified during the NOHS walk-through and have been reviewed for their toxic effects in humans and animals. In this regard, azo dyes have received the most attention. These dyes and pigments include the following monoazo materials:

- Basic Orange 2
- Pigment Red 4, 22, 49, 53 and 57

Diazo materials include:

- Direct Blues 6, 14 and 218
- Pigment Yellow 12

Triazo materials include:

- Direct Black 38
- Direct Brown 95

Diazo and Triazo dyes and pigments are chemical classes that contain many compounds derived from benzidine. Both benzidine and dianisidine are apparently metabolized from these materials and have been detected in the urine of persons exposed to Direct Blue 218 and Direct Black 38 (40,41).

Carcinogenic activity has been reported for several diazo and triazo dyes (40,41,42)*. These materials included:

- Direct Blues 6, 14
- Direct Black 38
- Direct Brown 95

In a current intelligence bulletin issued for Direct Blue 6, Direct Black 38 and Direct Brown 95, NIOSH recommended that these dyes be handled in the work place as if they were human carcinogens (43). In an occupational hazard review of benzidine-based dyes (44), NIOSH concluded that all these dyes should be considered potential human carcinogens. Both NIOSH and OSHA have issued a health hazard alert on benzidine-based dyes (41). This alert states that dyes derived from benzidine, such as those containing o-tolidine and o-dianisidine, are metabolically converted to benzidine and related compounds. The substitution of safer dyes for benzidine-based dyes has been recommended whenever possible by NIOSH (40).

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*Identified during the NOHS walk-through as carcinogens to which paper mill workers are exposed (see Table 58).

Stilbene dyes, such as Direct Yellow 11, are used as fluorescent brightening agents. These substances produce varying degrees of skin or eye irritation after dermal or conjunctival exposure (45). Animal experiments dealing with the carcinogenicity, mutagenicity, teratogenicity and reproductive effects of fluorescent brightening agents have produced negative results (38).

Diphenylmethane dyes (also known as auramines), such as Basic Yellow 2, have been considered as suspected carcinogens in humans (46) based on a review of two pertinent epidemiologic studies. A statistical survey of the British chemical industry during 1920-1952 indicated that occupational exposure to auramines was significantly correlated with excess risk of developing bladder tumors. In another study involving 191 auramine-exposed individuals at a BASF plant in West Germany from 1932 to 1976, the conclusion was drawn that auramine is not a carcinogen. NIOSH, however, indicated that incomplete and insufficient control data were cited in this report and that the results of this study should be regarded as inconclusive (46).

Triphenylmethane dyes, such as Basic Violet 14, are also known as magentas. In a study of British dye workers, it was found that the manufacture of magenta was associated with tumors of the urinary bladder (47). This study also associated an increased risk of bladder cancer with the manufacture of auramines.

Formaldehyde

Formaldehyde is very irritating to mucous membranes of the skin, eye, and respiratory tract. Formaldehyde vapors may also produce contact dermatitis (11). Prior exposure of skin to formaldehyde may sensitize individuals to subsequent exposures. Acute irritation of the respiratory tract has resulted in pulmonary edema, pneumonitis, and death (48).

A review of formaldehyde studies in the Russian literature indicates altered visual sensitivity and changes in brain electrical activity at a concentration of 1 mg/m^3 (48). However, other studies conclude that there is no relationship between the occurrence of eye disorders and chronic formaldehyde exposure. In addition, no acute effects of formaldehyde on visual function tests have been observed in workers exposed to formaldehyde levels averaging 0.5 mg/m^3 (49).

The only generalization that can be made from the few chronic studies reported in the literature is that chronic exposure to concentrations greater than approximately 1.2 mg/m^3 entail a risk of irritant effects on respiratory passages, eyes and exposed areas of the skin. Formaldehyde possesses both primary irritant and sensitizing actions, so that observable effects at or below 0.6 mg/m^3 may be mediated by the immune system. In such cases, no completely safe, innocuous exposure levels can be established; continued exposure may lead to sensitization. In addition, chronic exposure to formaldehyde concentrations that do not produce observable effects may predispose individuals to respiratory infections (50). Epidemiologic studies provide some positive evidence of this fact, although chronic levels of exposure are generally higher than concentrations producing minimal irritative effects. The resolution of this issue by appropriately controlled studies could be of value, especially in view of the widespread exposure of the general population to gaseous formaldehyde from various formaldehyde resins used in paperboard and textile products (1).

Sixteen cases of dematitis were described for workers in a plant in New Zealand that manufactured melamine-, urea-, and phenolic-formaldehyde resins for paper treatment (51). Despite wearing protective gloves and barrier creams, workers carrying rolls of treated kraft paper developed erythema of the face (including eyelids, neck, and forearms). Workers handling resins and brushing resin-impregnated sheets developed severe dematitis of the hands and neck. The highest formaldehye levels were measured between 20.0 and 37.4 mg/m^3 (5-10 times the OSHA standard).

By contrast, no statistically significant effect on visual functions tests of workers were found during exposure to formaldehyde levels that averaged 0.5 mg/m^3. Changes in visual sensitivity and brain electrical activity have been reported in workers exposed to 1.0 mg/m^3 (48).

Formic Acid

Formic acid vapor is a severe irritant of the eyes, mucous membranes and skin. Exposure causes eye irritation with lacrimation, nasal discharge, throat irritation, and cough (52).

The liquid on the skin causes burns with vesiculation; keloid formation at the site of the burn often results (53). Skin sensitization may occur in persons perviously exposed to formaldehyde (14). While an ingestion of the liquid is unlikely in ordinary industrial use, the highly corrosive nature of this substance may be expected to produce serious burns of the mouth and esophagus (8).

Hexachloroethane

This agent was identified during the NOHS walk-through as a carcinogen to which 0.5% of pulp and paper mill production workers are exposed.

Hexachloroethane is an eye irritant. At high concentrations, it causes narcosis in animals, and it is expected that severe exposure will produce the same effect in humans.

Exposure of industrial workers to fumes from hot hexachloroethane has resulted in blepharospasm, photophobia, lacrimation, and reddening of the conjunctiva. There has been, however, no corneal injury or permanent damage reported (8). No chronic effects have been reported from industrial exposure, although significant absorption through the skin is said to occur (8).

It is not known whether the 1 ppm TLV is sufficiently low to prevent chronic injury to all cases (8).

Hydrazine

Hydrazine acts as a scavenger by removing dissolved oxygen from aqueous solutions containing corrosive agents (54). Although data presented in Table 58 indicate that 0.1% of the NOHS worker group were exposed to hydrazine, the extent to which hydrazine is used for this purpose in pulp and paper mills is, otherwise, not known. The NIOSH-recommended exposure level of 0.04 mg/m^3 is based on the severity of toxic and carcinogenic effects reviewed by NIOSH. During this review, it was concluded that no demonstrably safe level of exposure is apparent from the available evidence.

Hydrogen Peroxide

Hydrogen peroxide is an irritant to the eyes, mucous membranes and skin. Inhalation of high concentrations of vapor or mist may cause extreme irritation and inflammation of the nose and throat. Exposure for a short period to mist or diffuse spray may cause stinging of the eyes and lacrimation. When splashed in the eyes severe damage may occur, including ulceration of the cornea; there may be the delayed appearance of damage to the eyes since corneal ulceration has, on rare occasions, appeared as much as a week or more after exposure (8).

Skin contact with the liquid for a short time will cause a temporary whitening or bleaching of the skin. If splashes on the skin are not removed, erythema and the formation of vesicles may occur. Although ingestion is unlikely to occur in industrial use, it may cause irritation of the upper gastrointestinal tract. In such cases, decomposition of hydrogen peroxide will result in the rapid liberation of oxygen, which may distend the esophagus or stomach and cause severe damage (8).

Hydrogen Sulfide

The NIOSH criteria document on hydrogen sulfide (55) states that hydrogen sulfide exposure is a leading cause of sudden death in the workplace. Brief exposures at high concentrations have caused conjunctivitis and keratitis, while exposures at very high concentrations have caused unconsciousness, respiratory paralysis, and death. Though the criteria document reports that conclusive evidence of adverse health effects from chronic, low-level exposures to hydrogen sulfide is not known, there is some evidence that hydrogen sulfide in low concentrations, either by itself or in combination with other chemicals, has caused nervous system, cardiovascular and gastrointestinal disorders, and effects on the eyes.

Respiratory tract irritation due to formation of alkali sulfide may result from hydrogen sulfide exposure, with long-term exposures leading to the development of brochitis and pneumonia (22). Penetration of hydrogen sulfide deeply into the lungs, as might occur in a hyperventilating worker, may produce a hemorrhagic pulmonary edema.

Harmful systemic effects of hydrogen sulfide may occur after acute or chronic exposure. Acute exposures may cause immediate coma, with or without accompanying convulsions; death may result from respiratory failure.

Subacute exposures generally result in headache, dizziness, staggering gait, excitement suggestive of neurologic damage and nausea and diarrhea suggestive of gastritis. In addition, tremors, weakness, and numbness of the extremities may result. Poisoned victims frequently exhibit abnormal electrocardiograms. It is currently thought that the toxic actions of hydrogen sulfide are due to its ability to bind iron and thus inhibit the cytochrome oxidase system, which is essential for cellular respiration (1).

The effects of repeated exposures to hydrogen sulfide may in some respects be cumulative. The inhibition of cerebral cytochrome oxidase activity may also take place in the human brain, which may lead to increased headache frequency, increased fatigue, and slow deterioration of mental functions sometimes seen in chronic human hydrogen sulfide toxicity (1).

Kerosene

Kerosene, which is used to control the build up of pitch (resins and fats) in pulping and papermaking equipment, is usually not hazardous as a vapor. However, if high concentrations are inhaled, headache followed by central nervous system depression may occur. Inhalation of jet airplane fuel, which is similar to kerosene, produces intoxication. During such exposures, there is a narrow margin between concentrations inducing narcosis and those producing lethal effects (9).

Magnesium Oxide

Because of the very slow absorption from the gastrointestinal tract, there is little danger from ingestion of magnesium oxide. If appreciable absorption does occur, however, signs of magnesium intoxication may occur. Symptoms include central nervous system depression and eventual respiratory paralysis (9). Inhalation of magnesium oxide fumes may result in fever and leucocytosis (13). In its powder form, magnesium oxide may irritate mucous membranes, resulting in a chronic nasopharyngitis (10).

Methyl Mercaptan

Methyl mercaptans affect the nervous system and cause both convulsions and narcosis; high concentrations cause paralysis of the respiratory center, while lower levels are associated with pulmonary edema. According to NIOSH, the primary reason for concern about worker exposure to mercaptans is mucousal irritation, producing respiratory changes that lead to respiratory failure, muscular weakness, paralysis, mild to severe cyanosis, coma, and death (1).

In a non-fatal accident, a worker in a refinery inhaled methyl mercaptan and was comatose for nine hours. Although not dyspneic, the individual was cyanotic and experienced convulsions; recovery occurred by the fourth day. Ten days later the worker was treated successfully for a lung abscess (8).

Polychlorinated Biphenyls (PCB)

PCB's were first discovered in the pulp and paper industry when folding cartons for packaging dried fruit were chemically analyzed. The source of PCB contamination was found to be carbonless copy paperstock, in which PCB was used as a component of the dye carrier system (56). During a study in which a variety of grades of pulp, paper, and paperboard samples were analyzed for the PCB's Aroclor 1242 and 1254 (57), 11% of the grades of paper contained PCB residues in excess of 126 mg/m^3 (some as high as 1,257 mg/m^3), including virgin bond paper and newsprint (1).

The American Paper Institute has indicated that the paper industry merely re-circulates PCB's, such as Aroclor 1242, that are already present in the environment through the use of recycled paperstock (58). Of the commercially available PCB's, those involved in carbonless copy paper are thought to be among the least stable, least environmentally persistent, and least susceptible to bioaccumulation (59).

As indicated in the NIOSH criteria document on PCB's (60), PCB's are mixtures of chlorinated biphenyls that have a variety of biologic effects in humans, including digestive disturbances such as anorexia, eye irritation, chloracne, skin and nail pigmentation, liver damange, impotence, and the potential for inducing carcinogenic and teratogenic effects. Their primary effects are on the skin (chloracne) and liver.

As with certain pesticides such as DDT, some PCB's (such as Aroclor 1254) inhibit human leucocyte functions (mitogenic response to phytohemagglutinin). On the basis of in vitro experiments, it has been proposed that inhibition of mitochondrial respiration, which leads to a decrease in intracellular adenosine triphosphate concentration in lymphocytes, may be responsible for Aroclor 1254's effect on leucocyte function (1).

Due to their complexity, the toxicity of PCB's is diffucult to determine. Splenic strophy and chemical porphyria appear to be general responses to PCB ingestion. PCB's are stored in body fat, and their toxicity may be potentiated by halogenated hydrocarbon solvents such as carbon tetrachloride (9). Adverse effects of PCB's from general environmental contamination have not been reported. However, a disease know as "Yusho" was reported in Japan in 1968 which was due to ingestion of rice bran oil contamination with PCB's. Signs of the disease incuded acneiform eruptions, secretion from meibomian glands of the eye, hyperpigmentation of skin, nails, and mucous membranes, swelling of the upper eyelids, and hyperemia of the conjunctivae (60).

Rosin

Although toxicity data are scarce and there is no OSHA standard or recommended exposure level for rosin, the oil is thought to produce dermatitis. Heated rosin is known to produce irritating vapors which may sensitize the respiratory tract (13).

Sodium Hydroxide

The principal hazards of sodium hydroxide (caustic soda) include eye contact, skin contact, ingestion, and dust or vapor inhalation (61). Eye injury (conjunctivitis and corneal burns) are probably the most severe effects from contact with sodium hydroxide. Inhalation may cause damage to the upper respiratory tract varying from a mild irritation of the mucous membrane to a severe pneumonitis. The dust may also cause an irritative dermatitis. Ingestion may result in nausea and abdominal pain with diarrhea, gastrointestinal tract perforation, and cardiovascular collapse.

In a review of available data on sodium hydroxide aerosols, the OSHA standard and NIOSH recommendation of 2 mg/m^3 was determined insufficient to protect workers' health (62). This review emphasized that the few published studies on the toxicity of sodium hydroxide do not consider the fact that the toxicity of sodium hydroxide dust or aerosol is affected by other factors in addition to sodium hydroxide concentration. Depending on the amount of water vapor and carbon dioxide present, the hydroxide will react with these agents to form the less alkaline sodium carbonate; this reaction will occur whether the hydroxide is in the form of droplets or solid particles. At relative humidities greater than 95%, sodium bicarbonate may also be present.

This review also suggested that the work done in determining human response to sodium hydroxide aerosols has been ill-defined, and concluded that (a) the eye may be the organ most vulnerable to sodium hydroxide aerosol damage, (b) improved sampling and exposure evaluation techniques should be developed to prevent formation of the carbonate before the hydroxide is delivered to its capture site, (c) physiochemical behavior of sodium hydroxide aerosols should be studied in greater depth to analyze more thoroughly available dose-response data, and (d) the standard for sodium hydroxide should be revised downward and a standard should be developed for sodium carbonate.

Sodium Hypochlorite

Occupational exposure to airborne sodium hypochlorite may result in irritation of the eyes, including corneal damage, and skin irritation with vesiculation and eczema. Inhalation of the particulate may cause cough, edema of the pharynx and larynx and lead to corrosion of the mucous membranes and pulmonary edema (10).

Sodium Sulfate

Sodium sulfate (salt cake), used in its anhydrous form is slowly absorbed from the gastrointestinal tract. The sulfate ion is said to be non-toxic (13). In a test of various particulate sulfate aerosols in asthmatic children and normal adults, no toxic effects to pulmonary function were revealed after 10 minute exposures of 10,100 and 1000 mg/m^3 (1). In an attempt to correlate absenteeism in workers with atmoshpheric particulate sulfates, it was concluded that no significant effect on absenteesium could be attributed to particulate sulfate concentrations up to 35 mg/m^3 (1).

Sulfur

Sulfur has a very low toxicity. Survival after ingestion of 60 grams of sulfur for a period of 24 hours has been recorded (9). Ingestion of large amounts may lead to the production of hydrogen sulfide due to bacterial action in the colon and subsequence systemic toxicity. Chronic inhalation of sulfur dust can cause irritation of mucous membranes and other effects of nuisance dusts (13).

Sulfur Dioxide

Sulfur dioxide is a severe irritant due to the rapidity with which sulfurous acid is formed when sulfur dioxide is in contact with moist, mucous membranes (63). In response to pulmonary irritation caused by inhalation of sulfur dioxide, reflex bronchoconstriction resulting in an increase in pulmonary flow resistance and mucous secretion occurs. Cases of suppurative bronchitis, enfluenza and asthma attacts have been reported. Asphyxia or severe chemical bronchopneumonia with bronchiolitis obliterans have been reported where the concentration of sulfur dioxide has been extremely high.

It is estimated that 10-20% of the healthy young adult population is hyper-susceptible to the effects of sulfur dioxide. Adaptation to normally irritating concentrations is a recognized occurrence in experienced industrial workers. Studies have shown that workers repeatedly exposed to concentrations of 10 ppm have experienced upper respiratory irritation and some nose bleeds; these symptoms did not occur at 5 ppm. In one study, initial cough and irritation did occur at 5 ppm and 13 ppm, but subsided after 5 minutes of exposure (8).

Exposure of the eyes to liquid SO_2 causes corneal burns and opacification resulting in a loss of vision. Liquified SO_2 on the skin produces skin burns from the freezing effect of rapid evaporation (8).

Sulfuric Acid

Sulfuric acid is extremely irritating to skin and mucous membranes. In concentrated form, it is corrosive and destructive to tissue by virture of its oxidizing and dehydrating effect and consequent liberation of heat. Corrosive burns may result from skin contact, ingestion or inhalation of fumes; a chemical pneumonitis may occur after exposure to vapors (9). Other effects of exposure to sulfuric acid vapors include pulmonary edema, chronic pulmonary fibrosis, bronchiectasis, and emphysema. Subjective effects including throat tickling and scratching, have been reported at concentrations of less than the recommended standard of 1 mg/m^3 (64). Concentrations of 5 mg/m^3 are known to cause cough, with an increase of respiratory rate and impairment of ventilatory capacity. Repeated exposure of workers to the mist causes chronic conjunctivitis, tracheobronchitis, stomatitis, and dermatitis (8). Workers exposed to concentrations of 12.6 to 35 mg/m^3 had a marketedly higher incidence of errosion and discoloration of teeth than was noted in unexposed individuals (64).

Splashed in the eye, the concentrated acid causes extremely severe damage often leading to blindness; the dilute acid produces more transient effects from which recovery may be complete. While ingestion of the liquid is unlikely in ordinary industrial use, the highly corrosive nature of this substance will produce serious burns of the mouth and esophagus (8).

Tetrachloroethylene

This commonly used cleaning agent was identified during the NOHS walk-through as a carcinogen to which 0.9% of pulp and paper mill production workers are exposed. In addition to its effect as a carcinogen, tetrachloroethylene causes central nervous system depression and liver damage; chronic exposure has caused peripheral neuropathy. Symptoms of central nervous system depression during occupational exposure include dizziness, light-headedness, inebriation and difficulty walking. Prolonged exposure has caused impaired memory, numbness of the extreminies, and impaired vision (65).

On the skin, the liquid may result in a progressively severe burning sensation and marked erythema (8).

Thiourea

This material is identified as an NOHS carcinogen to which 0.2% of the pulp and paper mill production worker group are exposed. It is said to cause depression of bone marrow with anemia, leukopenia and thrombocytopenia, and may also cause allergic skin erruptions. When heated dangerous and highly toxic fumes of oxides of sulfur (decomposition product) may be emitted (13).

Titanium Dioxide

Titanium dioxide is a white pigment that is available in two lattice forms: anatase and rutile. The anatase form was primarily used as a filler in the pulp and paper industry until after World War II; now this compound is used primarily as a coating pigment. Titanium dioxide and other titanium pigments are usually purchased by mills in 50 pound kraft bags, printed with water soluble inks, so that the unopened bag can be added directly to the pulp stock (1).

Titanium dioxide is considered physiologically inert, since no cases of intoxication have been reported in the literature. The oral lethal dose in humans in said to be above 15 g/kg (9). A case has been described where no apparent harm or distress resulted from the ingestion of one pound (0.45 kg) of titanium dioxide (9).

The dusts of titanium may be considered nuisance dusts. However, it is not clear from available evidence whether pneumoconiosis may result from exposure to titanium dioxide (13). Clinical studies have reported production of fibrotic changes in the lungs after exposure to titanium dioxide pigments (66). Such changes, however, could not be linked to the pigments alone, since titanium dioxide pigments are usually covered with coatings which may contain inorganic and organic substances and may also be of sufficent size to cause lung irritation and damage. The inorganic substances may include oxides of aluminum, zinc, and other metals. Organic materials such as isopropanolamine may be used to prevent caking of the titanium dioxide pigments during manufacture (67).

Trichloroethylene

This cleaning agent was identified during the NOHS walk-through as a carcinogen to which 0.5% of the pulp and paper mill production worker group are exposed.

Acute exposures to this agent result in central nervous system depression and mild irritation to the respiratory tract. Injuries to the cardiovasular and gastrointestinal systems, as well as to the liver and kidneys, have also been reported (8).

Chronic exposure to trichloroethylene may produce double vision, changes in color perception, blindness, loss of coordination and sense of smell, and impairment of the tactle senses. Intolerance to alcohol, tremor, giddiness, bradycardia and anxiety have been found in workers chronically exposed to 5-630 ppm (68). A particular dermal response resulting from the ingestion of alcoholic beverages after repeated exposure to trichloroethylene has been described as consisting of cutaneous vasoldilation of the face, neck, shoulders, and back. It has also been suggested that ingestion of alcohol may potentiate the effect of trichloroethylene intoxication (69).

The liquid can penetrate the skin. Prolonged skin contact may cause irritation and formation of vesicles. Repeated emersion of hands in the liquid has caused paralysis of the fingers. A few drops of the liquid in the eye will result in transient pain and conjuctival irritation (8).

Turpentine

Crude or sulfate turpentine recovered from pulp digestion in the kraft process is another major byproduct of sulfate pulping where wood from pine trees of high resin content is used. The composition of this form of derived turpentine is approximately 50-60% alpha-pinene, 15-20% beta-pinene, and 10-15% monocylic terpenes. Other components may include limonene, phellandrene, and delta-3-carene. The terpene p-cymene is also a component of sulfite turpentine formed during acid pulping of firs and spruces (1).

Turpentine is irritating to eyes, nose, and bronchi; contact dermatitis may result from exposure to the liquid. Vapor inhalation and percutaneous absorption are the most frequent routes of occupational exposure to turpentine. Both routes of exposure may result in symptoms of central nervous system stimulation followed by depression and kidney and bladder damage (chronic nephritis with albuminuria and hematuria) (22). Specific symptoms include buring pain in throat, coughing and choking, dyspnea, transient excitment followed by ataxia, delirium, stupor, fever and tachycardia. The odor of turpentine may be on breath, while the urine may have an odor of violets. Death is usually due to respiratory failure (9).

Aspiration may lead to pulmonary edema and pneumonitis. Since turpentine is readily absorbed from the skin, respiratory tract and gut, many accidential poisonings have been reported.

Wood Dust

A review of the literature on health hazards from wood dust identifies contact dermatitis, allergic respiratory reactions, systemic poisoning, and adenocarcinoma of the nasal sinus as the major disease entities. However, these conditions are not generally associated with all types of wood or with all operations involving exposure to wood dust.

Contact dermatitis, resulting from primary irritation and allergic sensitization, has been reported. Chemical components of wood, such as alkaloids, lucosides, saponins and quinones have been suggested as mediators of allergic sensitizations and systemic effects attributable to wood dust (70).

Allergic respiratory reactions to a number of woods during inhalation studies have also been confirmed. The production of wheal and flare responses during skin tests of wood extracts and the induction of reversible airway obstruction suggest an immunoglobin E-mediated response (71). In a case of sensitivity to cocabolla (one of over 50 varieties of wood that can produce dermatitis), desensitization was accomplished using a series of 18 injections of 2% saline solution of wood dust (70,72).

Wood, bagasse, and cotton products are sources of airborne agents, such as molds, fungi, or their metabolic products, that may be released during wood handling or pulp processing. These airborne agents may lead to respiratory disorders.

Case histories of a hypersensitivity pneumonitis in 2 paper mill wood-room workers described recurrent episodes of dyspnea, chills, weight loss, and fever, usually occurring at night. In both cases, the patients sought medical treatment, but the cause of the disease was not discovered for a number of years. The patients improved without specific therapy after prolonged periods (3-6 weeks) away from work. They responded specifically to the inhalation of an extract of the fungus, Alternaria, which resulted in slight reactions immediately, with much more severe reactions occuring after 6-8 hours. When steriods were administered, symptoms cleared within 24 hours. In both patients, permanent lung disability occurred, ascribed by investigators to the delay in accurate diagnosis and continued exposure. Lung biopsies of both patients showed chronic interstitial pneumonitis.

Cancer of the nasal sinus has been associated with exposure to wood dust, with the majority of such cases occurring in the furniture industry. In England, adenocarcinoma of the nasal sinuses in woodworkers was made a prescribed (compensable) disease in 1969. However, there is no firm evidence implicating specific varieties of wood with the development of nasal adenocarcinoma.

Several reports have associated lung cancer and Hodgkin's disease with wood dust in the paper industry. Cancers of the larynx, buccal cavity, pharynx, colon and rectum, however, are said to be more common in paperworkers than is lung cancer (1). This finding is notable, since lung cancer accounts for 20% of cancer deaths in white males, far more than any other cause, except for gastrointestinal cancer in older age groups. Excess multiple myeloma and cancer of the small intestine has also been known to occur in pulp and paper workers. Studies associating pulp and papermaking with nasal and other cancers have been based on death certificate surveys or on a comparison of death rates between counties with or without a papermaking industry. No studies have been identified which examine standard mortality ratios for workers in the pulp and paper industry when compared to other groups. This is in contrast to a number of studies from several parts of the world which have identified nasal sinus cancer patients as more likely to be furniture woodworkers than workers of other occupations (1).

An important distinction between the pulp and paper industry and the wood finishing industry is that wood finishing involves several operations, such as shaping, cutting, and sanding, which generate large amounts of fine wood dust. Thus, human effects associated with fine wood dust may not be as prevalent in the pulp and paper industry as in the wood finishing industry (1).

Zinc Oxide

Skin lesions from prolonged skin contact with zinc oxide have been reported (73). Metal fume fever may also be caused by the inhalation of clouds of zinc oxide powder. Zinc, when heated (as in welding operations), gives off fumes of zinc oxide. These fumes may induce a transitory influenza-like illness with symptoms including chills, fever, aches, dry cough and vomiting (9). Workers exposed to zinc powder or zinc oxide powder may experience naso-pharyngitis and laryngitis (73).

Zinc oxide has been used for many years in the topical treatment of skin disorders and has been shown to be absorbed systemically after topical administration to intact skin. Long-term exposure to zinc oxide dusts or materials might produce eventual systemic effects, but the likelihood of this effect from exposure to zinc oxide pigments in the paper industry appears to be small (1).

CONTROL OF EXPOSURE

Some of the potential chemical hazards arising from the production of pulp and paper require the use of personal protective equipment, safe-work practices, safety training programs, and engineering controls in a coordinated effort to control worker exposure. Protective equipment can be divided into the three following categories:

- Equipment to be worn constantly because hazards exist as a result of continuing operations (routine use)

- Equipment to be worn only when certain operations are performed (occasional use)

- Equipment to be worn in emergencies (emergency use).

Current OSHA standards require employers to provide protective equipment and devices to workers engaged in various operations. These operations and equipment are summarized in Table 68 and are based on general and consensus standards for the control of chemical hazards in the work place and the industry standard governing pulp, paper, and paperboard mills as presented in 29 CFR 1910.261 (see Appendix D). According to OSHA, many operations and work areas require special protective equipment and devices. These areas must be posted, and management must enforce the use of the necessary equipment for each worker's safety and of the safety of others. A complete safety in-house program should incorporate the use of safety devices and procedures in any standard equipment operating manual. Constant attention to training and retraining is also necessary. These training programs must describe the limitations of the various protective equipment and devices, how they are used and the operations requiring their use.

Protective equipment and devices must be inspected and cleaned after each use. In the case of emergency equipment, a periodic inspection and testing program is essential. Proper maintenance and cleaning procedures are also necessary including adherence to the recommendations of manufacturers. The selection of appropriate units must be done by a knowledgeable individual, familar with the operations to be performed and limitations of the equipment.

Industrial hygienists and other safety and health professionals are becoming increasingly aware of the significant problem in selecting protective clothing. Recommendations for the selection of materials for the fabrication of protective clothing are often not substantiated by tests for permeation or degree of protection. Some manufacturers now test for materials to determine whether they are impervious to specific chemicals. Users should always question their supplier about the products they use and should require data to support suppliers' claims.

Many operations in pulp and paper manufacturing involve a significant risk of worker exposure to airborne chemical agents. Exposure can arise from routine operations, from occasional maintenance or repair, and in an emergency situation. A thorough and complete respiratory protection program meeting the requirements of the OSHA standards is necessary (29 CFR 1910.134). The required equipment in such a program includes simple air purifying devices, self-contained breathing apparatus, emergency escape gas masks and air supply devices. Specific requirements have been listed in Table 68.

For respiratory protective equipment, a program of at least monthly routine inspections is necessary. These units should be stored so that a quick visual check will reveal any units that have been used or opened. For gas masks, canister expiration dates should be prominently displayed in storage areas so that out of date units can be identified easily. Units should be removed from service and deteriorating parts should be replaced during annual or more frequent inspections. Similar programs of inspection and maintenance are also necessary to assure the effectiveness of air purifying and air supply respirators. For emergency use, self-contained breathing apparatus is necessary. These programs can be expensive, but when they are operated properly, the cost can be tolerable (1).

Table 68 OSHA STANDARDS FOR PERSONAL PROTECTIVE EQUIPMENT USED IN PULP AND PAPER MILLS

Operation	Paragraph	Required Equipment	Type of Use
Raw material storage (handling dusty materials)	d(1)i	Respirators, half-mask with goggles or full-face type	Occasional
(handling liquid acid or alkali)	d(1)ii	Eye, face, and full body	Occasional
Chemical pulping operations - acid department	g(2)	Gas masks (for acids, gases, and mists involved), supplied air respirators	Occasional & Emergency
Inspection, maintenance and repair of towers		Eye protection, supplied air respirators, and lifelines	Occasional
Entering acid tanks	g(4)	Supplied air-respirators and lifelines	Occasional
Lime slaking	g(5)	Rubber boots, rubber gloves, protective aprons, and eye protection	Occasional
Lead burning (within tanks)	g(6)	Supplied-air respirators	Occasional
Digester building	g(10)	Gas masks (sulfurous acid and chlorine protection required)	Emergency
Blowing digester (clearing stock)	g(14)ii	Eye protection and protective clothing	Occasional
Inspecting and repairing digesters	g(15)	Supplied-air respirators made available, lifelines, and protective headgear	Occasional
Removing brick lining		Eye protection and dust respirators	Occasional
Bleach mixing rooms and rescue work	h(2)	Gas masks, supplied-air respirators, and self-contained oxygen masks	Emergency
Liquid chlorine storage rooms and rescue work	h(3)	Gas masks, supplied-air respirators, and self-contained oxygen masks	Emergency

Full-face respirators should be used for emergency escape operations. Many of the compounds which can be immediately dangerous to life or health when present are also severely irritating to the eyes. The protection afforded by full-face respirator masks can allow the worker to escape an atmosphere that could be otherwise disabling. A major source of difficulty with respirators is the problem of obtaining an adequate facial seal. Beards, long mustaches, and sideburns, prevent an inadequate seal, and glasses can not be worn effectively with full-face units. A positive pressure type self- contained breathing apparatus circumvents these leakage problems. A complete respiratory program should also include medical certifications of worker fitness to perform the job while wearing these units.

Air sampling for the proper selection of correct personal monitoring devices and other equipment and training of workers and supervisors in their use should also be part of the program. Gas chromatography may be used to distinguish the various gases present. Measurements by gas chromatography of gas concentrations in worker areas should be more useful than personal monitoring devices for defining general conditions, and to provide results that can be related to process and equipment operating variables. A procedure to calibrate personal monitoring devices against gas chromatography may, therefore, be quite beneficial. The results of such a procedure would also indicate the maximum exposure for someone who spends the whole work day at various operating areas. Other details of adequate programs are specified in agent specific OSHA standard and NIOSH criteria documents.

Many chemical hazards can be prevented by the use of safe-work practices and adherence to safety regulations established for the pulp and paper industry. Many practices that would appear to be "common sense" rules not followed uniformly by workers or enforced uniformly by employers. In this regard, supervisors should be required to insist that workers be trained in safe work practices and relevant regulations. In wood yards (pulpwood preparation), for example, the use of respirators with goggles or protective masks are required according to OSHA 1910.261 when handling alum, bleach powder, chlorine, lime, soda ash, and sulfur and when opening bag bales when such materials are not controlled at the source. In another example, many workers are subject to fatal chemical hazards if safe work practices are not followed in the stock preparation areas of chemical pulping operations (7). Rushing to help a fellow worker involved in a vessel entry incident without using proper breathing and other protective equipment is one common error attributed to vessel entry fatalities. OSHA 1910.261 presents requirements for protection of workers during vessel entry procedures.

Exposure to sudden high concentrations of pulping effluents such as hydrogen sulfide is a frequent hazard that may result in death by asphyxiation. The use of a detector with audible and visual alarms activated by excessive concentrations, combined with worker training to don respirators or other protective equipment when the alarm occurs, may decrease the source of fatal chemical accidents. The use of respirators in dusty areas can also protect workers. Problems associated with using this equipment in hot, humid working environments should be addressed by an occupational health program consultant who can assist representatives of workers and management in determining individual plant needs for protection. The effectiveness of safety regulations and work practices will depend on the amount of worker training, as well as the incentive or enforcement needed to continually observe these practices.

An idealized approach to the establishment of a plant safety program was defined by an industrial engineer (74), and includes the following procedures:

- Become familar with the Occupation and Safety Act of 1970 and maintain an OSHA log of occupational illnesses and injuries.
- Perform a walk through survey of the plant with someone familar with the type of business but not with the specific plant.
- Record hazards at each site; a helpful context to determine whether a condition may be hazardous is to ask: "How could a worker's health be affected performing a task here?", and "Would I want to work under these conditions on a permanent basis?".
- Examine the resulting hazard list and classify each injury on the basis of estimated correction time and estimated cost of correction. Set priorities to correct certain hazards as soon as possible; for others, set deadlines with phase completion dates and progress reports, as needed.
- Have a worker representative participate in an OSHA compliance inspection.
- Perform regular safety reviews of all plant layouts.
- Establish pre-employment physical examinations for all workers with periodic examinations for monitoring specific health conditions.
- Devise an information gathering system for keeping currently aware of safety regulations.

CREWING AND EXPOSURE PATTERNS

Of the many process and by-product chemicals occurring throughout the pulp and paper industry, exposure conditions have been assessed only for some chemicals. For the vast majority of chemicals, information on work place emission sources, worker exposure and other characteristics is scarce. Needs to gather such data have been tempered by the fact that many chemicals occur in such small quantities that worker exposure problems have not been considered serious (75). The preparation, handling and utilization of many chemicals is performed in a manner which isolates the worker from exposure due to the high degree of process automation, as well as workers remaining in control rooms, acoustical booths and other enclosed spaces. After one previous NIOSH investigation of pulp and paper industry worker exposure to chemicals was completed, the project officer stated that a full blown field testing program would be needed to assess exposure conditions for most chemicals and that, due to the low exposure potential and the high degree of worker isolation to many chemicals, further work would not be justified (75).

However, a more recent NIOSH study provided significant new data on chemical work place contaminants, emission sources and the potential for worker exposure (76). This study was conducted to evaluate and document worker exposure to toxic chemicals and harmful physical stresses and related controls to exposure used in the pulp and paper industry. In this study, in-depth surveys were conducted at 18 mills. From this effort, general crewing and exposure patterns have been developed in this section for the following unit processes:

- Wood preparation.
- Kraft pulping and brownstock washing.
- Kraft chemical recovery (black liquor evaporators and recovery furnaces).
- Kraft chemical recovery (recausticizing and lime burning).
- Sulfite pulping and brownstock washing.
- Bleach chemical handling and preparation operations.
- Multi-stage pulp bleaching.
- Mechanical pulping.
- Papermaking operations.

The generalized job categories and descriptions presented in this section have also been developed largely from this NIOSH survey of specific unit operations and plant production processes.

Because mills combine work tasks depending on equipment layout, automation and complexity, specific job titles and responsibilities, as well as the number of required workers and the tasks they perform, vary considerably throughout the industry. Such wide variations in these categories create job descriptions that are generally not comparable. Generalized job descriptions are therefore difficult to establish. It also has been suggested that occupational exposure characteristics for each machine type would be best determined on a plant by plant basis for each paper type (77).

Regarding the nature of work shifts, most of the pulp and paper industry works on the type of shift rotation schedule presented in Table 69 (77).

TABLE 69 TYPICAL SHIFT ROTATION SCHEDULE

Days	Shift
4	11-7
2	Off
4	3-11
2	Off
4	7-3
5	Off

Such a shift structure is designed to rotate workers' shifts over a 3-week period at operations that run four shifts per 24 hour day (one shift is off), 7 days per week. Generally, all pulping and papermaking processes operate this way. Exceptions occur in woodyards and in paper converting operations, where operations close down at night and on weekends (77).

Since the Case Studies presented later in this section may serve to supplement this section's approach to establishing general crewing and exposure patterns, the reader will be referred to appropriate Case Studies presented in the next section in the context of the following discussions.

Also, the Study Area analyses presented in Sections 4 and 5 include discussions and illustrations of equipment, machinery and process operations that should serve as a guide to assess the need for further work to characterize occupational exposure in operations not addressed in this section or in the Case Studies of specific occupational problems presented later in this section.5.

Wood Preparation

The wood preparation operations observed during the NIOSH survey are typical of operations employed at most pulp mills. In such an operation, roundwood is typically washed with high pressure water jets, slashed (cut to size), debarked and then shipped or sent directly to the pulp mills.

The major potential contaminant to workers in the wood preparation process is wood dust. During the NIOSH survey, observations indicated that dust exposures were low, primarily because most operations are conducted on wet material and effective housekeeping is employed.

In Table 70, job categories and descriptions for a typical wood preparation operation are presented along with the estimated number of workers per shift. Included in this table are the results of personal air sampling conducted during the NIOSH survey for exposure to nuisance dust. As indicated in this table, all total dust exposures were below the OSHA PEL of 15 mg/m^3 for total nuisance dust.

Table 70 JOB CATEGORIES AND DESCRIPTIONS AND NUISANCE DUST EXPOSURE FOR PULPWOOD PREPARATION WORKERS

Job Categories	Number of Workers/ Shift	Job Descriptions*	Total Nuisance Dust (mg/m^3)	
			Range	Mean
Log unloading crane operator	1	Unload river rafts (75%)		
Haul-up crane operator	1	Transfer classified logs to woodroom conveyor (75%)		
Steam barker operator	1	Clear jams; inspection; housekeeping	0.10-0.51	0.26
Slasher operator	1	Monitor feed conveyor (90%)	0.04	0.04
Drum barker operator	1	Inspect debarked logs	0.20-3.4	1.8
Chip line operators	2	Monitor chipping lines (75%)		
Utility	2	Housekeeping		

*Estimated time spent in control rooms, booths, etc., is shown in parentheses.

Kraft Pulping and Brownstock Washing

During kraft pulping and brownstock washing operations, wood chips are typically cooked in sodium hydroxide and sodium sulfide solutions at high temperature and pressure in large batch or continuous digesters. The pulp is then deknotted (undefibrated, partially cooked wood particles removed), washed, and pumped to the bleach plant or directly to the paper mill. Unbleached (brown) stock washing is done to remove the spent cooking liquor from the wood fibers. This may be accomplished in several ways, including 2- to 4-stage washers with vacuum filters, in-digester washing, and diffusion washers. The most common system is the 3-stage system using rotary filters and counter-current washing. Pulp, suspended in black liquor, is pumped to the first filter where it forms a cake which is washed by effluent from the second filter. The effluent from this stage (black liquor) is sent to the recovery unit to reclaim the chemicals used in cooking. The cake is redispersed in the No. 2 filter washings and then pumped to the second filter. The cake formed here is washed by effluent from the third filter and then redispersed in the same type of effluent. Cake formed on the No. 3 filter is washed with fresh hot water.

Specific titles and responsiblities vary considerably throughout the industry for this type of operation. In general, there are five broad job categories. These include:

- Digester Operators
- Chip Feeders
- Wash and Screen Operators
- Quality Control Testers
- Utility Employes

Digester operators spend nearly all of their time in a control room where process operations are monitored, leaving the control room only for brief periods. Tasks which may require a digester operator to leave the control room would include collection and testing of digester samples during a particular cooking cycle, inspection and adjustment of equipment, and communication with the washer operators or other personnel. Many digester processes are almost entirely automated and the operator has all the controls and monitors he requires within the control room. Cameras and viewing screens are often provided so that he can periodically check remote process areas, such as the chip loading mezzanine.

Chip feeders load the digesters at the beginning of each cooking cycle. This is primarily a manual task, requiring about 20 minutes for completion. During this task, employees remove the digester lid and position the chip feeder hopper over the open digester; the vessel is then filled with chips. The chip feeder then removes the hopper and manually recaps the digester. Since these operations are repeated frequently, a chip feeder may spend most of his shift outside the control room.

Wash and screen room operators monitor and control the operations of washer lines, screens, filtrate tanks and high density storage tanks. In operations with no control room in the washer area, employees may spend essentially the entire shift in the production area, usually at operating consoles.

Testers are responsible for retrieving and analyzing production area samples such as white liquor, pulp from the digester, black liquor, and pulp and brown water from repulping vats. Samples are analyzed in laboratory areas located away from the production area such as a wash/screen control room. Testers typically remain in the control room for 80% of each shift.

Utility employees are responsible for keeping the pulp mill clean, conducting routine maintenance operations and assisting operators. It is estimated that utility employees typically spend 60% of each shift in the production area.

The primary air contaminants of concern to kraft pulping and brownstock washing workers include hydrogen sulfide, methyl mercaptan, dimethyl sulfide and dimethyl disulfide. There is also a potential for exposure to wood dust, particularly while digesters are being filled with chips. Much smaller quantities of turpenes, alcohols and potentially many other compounds may also be present.

The staffing arrangement for such an operation varies widely depending on the degree of process automation. In Table 71 the general job categories discussed above are presented along with the range of estimated number of employees for each shift. Also shown in this table are the results of personal samples collected during the NIOSH survey for nuisance dust, hydrogen sulfide and methyl mercaptan. These samples were taken during periods when employees were out of the control room for at least five minutes. The results, therefore, represent the highest probable exposure from routine operations.

Table 71 GENERAL JOB CATEGORIES AND EXPOSURES DURING KRAFT PULPING AND BROWN STOCK WASHING

Job Category	Est. No. of Employees/Shift	Nusiance Dust (mg/m^3)		Hydrogen Sulfide (ppm)		Methyl Mercaptan (ppm)		Percent of Shift Spent in Control Room
		Range	Mean	Range	Mean	Range	Mean	
Digester Operator	1-2	0.56-2.48	1.35	0.05-0.86	0.35	<0.03-4.5	<0.79	70-95
Chip Feeder	0-2	0.3-0.4	0.35			0.6-3.3	1.7	0-70
Wash and Screen Room Operator	0-2			0.05-0.33	0.12	<0.03-3.5	<0.71	0-90
Tester	0-3			<0.04-0.80	0.15	<0.02-1.9	<0.16	50-90
Utility	0-1			<0.01-0.20	<0.13	<0.05-1.0	<0.37	30-40

Worker exposure in kraft pulp mills is usually well controlled by a combination of the following factors:

- Process Characteristics - Continuous pulping processes are almost totally closed, and there are no persistent sources of work place contamination. Air contaminants are periodically emitted when batch digesters are open during chip loading operations; however, low exposures, regardless of the type of loading system, have been demonstrated.

- Worker Isolation - Because kraft pulping processes are highly automated, most operators and other employees spend considerable portions of each shift inside various types of control rooms. Many of these control rooms provide protection from work place air contaminants during leaks or process upsets.

- Brown Stock Washer Ventilation - Washers are exhausted through canopy hoods or full enclosures, with air flows effective in preventing work place contamination.

- Environmental Control - Noncondensable gas collection systems installed to prevent or reduce air pollution also reduce work place exposures.

Kraft Chemical Recovery - Black Liquor Evaporators and Recovery Furnaces

Spent black liquor is concentrated in multiple-effect vacuum evaporators, may be stabilized in oxidation towers, and is then pumped to a deaeration tank to remove entrapped air. The evaporator condensate, collected in one or more hot wells, is either pumped to a stripping tank or sewered. The noncondensable gases may be vented to an incinerator or to a lime kiln. From the deaeration tank, liquor is pumped through the bottom of an electrostatic precipitator, a chemical ash tank, and two ash hoppers to recover additional solids. The liquor overflows the hoppers into a cascade evaporator where it contacts hot flue gases for additional evaporation. It is then pumped through a salt cake mix tank, and injected with steam in primary and secondary heaters. Finally, the concentrated liquor is sprayed into the center of a hearth in a recovery furnace. Organic compounds are combusted, and the inorganic compounds are oxidized and melted, and flow down into a smelt bed. These molten chemicals are reduced, and then discharged through water-jacketed smelt spouts into a dissolving tank. The resulting green liquor is pumped to green liquor mixing or storage/clarification facilities in the recausticizing area.

Evaporators are typically operated by a single employee whos duties include monitoring and controlling the process, taking periodic temperature and specific gravity measurements of the strong and weak black liquors, conducting water and acid boil-outs (cleaning) of the evaporators, conducting periodic inspections of the process equipment and recording process data in production logs. The operator is usually inside a control room for about 80% of each shift.

Recovery furnances are normally operated from a control room where the operator monitors and adjusts the process and conducts frequent equipment inspections. It is estimated that he spends 90% of each shift in a control room. A helper cleans the char bed boards, clears smelt spouts and collects and tests process samples. He remains near the furnaces for most of each shift.

During the NIOSH survey of such an operation, personal samples were collected for hydrogen sulfide for the evaporator operator during routine inspection tours and quality control sampling runs. Approximately half of these samples were taken while evaporators were being boiled out with water. None of the samples resulted in exposures above 0.13 ppm, which is well below the OSHA ceiling PEL of 20 ppm. In twelve of the samples (75%), no hydrogen sulfide was detected (detection limits range from 0.01 to 0.07 ppm). It was determined from these samples that worker exposure to hydrogen sulfide is usually very low during normal operation conditions, primarily because evaporators and associated equipment are closed and located outdoors.

Recovery furnace building area samples were analyzed during the NIOSH survey for hydrogen sulfide, sulfur dioxide and methyl mercaptan. Sulfur dioxide was not detected (less than 0.002 ppm) in any of the samples. Methyl mercaptan samples ranged from 0.02 to 0.24 ppm and hydrogen sulfide levels ranged from 0.01 to 0.65 ppm. From these area samples it was determined that employee exposure to air contaminants in recovery furnace buildings should be low unless there is a major upset.

Process characteristics and worker practices that typically prevent employee exposure to significant levels of hydrogen sulfide or other contaminants include:

- A totally closed process.
- Evaporators and other equipment being located outside and well maintained.
- Operators stationed inside control rooms.
- The venting of noncondensable gases to an incinerator or to a lime kiln.
- Piping of contaminated process water to a feed tank where contaminants are stripped with air or passed through sealed drains into a pulp mill sewer.
- Work place monitoring and alarm systems for hydrogen sulfide.

Kraft recovery furnace characteristics that may reduce employee exposure potential to air contaminants during normal operation include:

- A totally closed process (excluding leaks, process upsets and certain maintenance activities).
- Location of all process tanks and equipment outside where natural ventilation can disperse and dilute any emission of contaminants.
- Operation of recovery furnace at negative internal pressure, effectively preventing the escape of gases.

Kraft Chemical Recovery - Recausticizing and Lime Burning

Two important operations in recovering kraft pulping chemicals are: 1) reacting (causticizing) green liquor (sodium carbonate and sodium sulfide) with quicklime (calcium oxide) to form fresh white liquor (sodium hydroxide and sodium sulfide) and lime mud (calcium carbonate); and 2) burning (calcining) the lime mud in rotary lime kilns to regenerate quicklime. The overall major steps in these two interrelated operations are:

1. Clarifying (settling) green liquor.
2. Slaking (dissolving) quicklime with green liquor, and removing (classifying) insoluble matter (dregs) [$CaO + H_2O \longrightarrow CA(OH)_2$].
3. Washing the dregs to recover lost sodium.
4. Causticizing the green liquor with calcium hydroxide (formed during the slaking step) to make white liquor and insoluble lime mud [$Na_2CO_3 + Ca(OH)_2 \longrightarrow 2\ NaOH + CaCO_3$].

5. Clarifying the white liquor, and separating and recovering the lime mud.

6. Washing the lime mud to recover lost sodium.

7. Thickening the lime mud.

8. Burning the mud in rotary kilns (or fluidized bed calciners) to convert it back to quicklime ($CaCO_3 \longrightarrow CaO + CO_2$].

Equipment used to perform these steps can vary from mill to mill, but is usually very similar.

The major tasks performed by workers in such an operation include:

- Process monitoring and control (performed inside a control center located near the kiln firing ends).
- Equipment inspection and manual adjustments and cleaning mud and white liquor filters (if used).
- Process control sampling and testing.
- Housekeeping and spill cleanups.

The number of workers and specific duties in such an operation depends on the number of kilns and/or liquor causticizing lines, and degree of process automation.

In Table 72 general job categories and tasks descriptions are presented for a recausticizing and lime burning operation. Also shown in this table are the results of personal air monitoring samples taken during a NIOSH survey of this type of operation.

Table 72 GENERAL JOB CATEGORIES AND TASK DESCRIPTIONS AND EXPOSURE IN KRAFT CHEMICAL RECOVERY - RECAUSTICIZING AND LIME BURNING

Job Category	Job Tasks	Est. No. of Workers/Shift	Nuisance Dust (mg/m^3)		Hydrogen Sulfide (ppm)		Mercaptan (ppm)	
			Range	Mean	Range	Mean	Range	Mean
Operator	All process monitoring and control operations and direction of other workers.	1-2	0.15-0.51	0.37	<0.1	<0.1	<0.4	<0.4
Helper	Process quality control sampling and testing. Operation and servicing of white liquor and lime mud filters.	0-2	9.38-20.05	12.67				
Utility Worker	Housekeeping and spill clean-up.	1	1.14-2.81	1.70			<0.1	<0.1

The primary work place contaminants during routine operations is process dust, which can be a variable combination of quick lime, limestone, calcium hydroxide, sodium sulfide and other minor inorganic salts. Quick lime or limestone is probably the predominant component in direct kiln emissions, but work place dusts undoubtedly vary widely in composition and potentially contain wood dust and other environmental particulates.

Process dust proposes the greatest exposure risks. Failure of kiln air seals or leaks in kiln exhaust, hot line transport or the slaker feed system can result in dust emissions and work place contamination. However, only workers who are frequently outside the control room (utility, testing, and operators at the kiln exhaust) are probably at risk of overexposure. Respirators and other personal protective equipment are often worn by workers cleaning up dust spills. Canopy type exhaust hoods are often placed over indoor lime mud (and white liquor) filters to contain and remove steam. Canopy type hoods may also help control the escape of hydrogen sulfide (from the white liquor) and hydrochloric acid (from the washing solution) during filter cleaning.

Factors which may influence the control of dust and other contaminants include:

- Process Characteristics - Most dust-handling equipment is closed and automated; significant quantities of hydrogen sulfide or other reduced sulfur gases do not normally off-gas from green and white liquor.

- Equipment Isolation - Kilns, lime storage silos, slakers, causticizers, and green and white liquor clarification and storage tanks are usually outside; lime mud filters are usually inside unoccupied buildings at a kiln feed/exhaust end.

- Worker Isolation - Except for utility workers, all other employees are inside protective control rooms for over 50% of their shift.

- Dust Emission Controls - Kiln exhaust cyclones and scrubbers, and slaker and lime silo vent scrubbers, are commonly used.

- Respiratory Protection - Disposable dust masks for workers.

- Housekeeping and Spill Cleanup Procedures

Sulfite Pulping and Brownstock Washing

Typical major unit operations associated with sulfite pulping include:

1. Preparation of pulping liquor (acid sulfite, bisulfite, or neutral sulfite) by:

    a. Burning liquid sulfur in rotary burners to produce sulfur dioxide gas.

    b. Cleaning and absorbing the sulfur dixoide gas in soluble chemical solution (usually in packed towers).

c. Fortifying (strengthening) this weak fresh liquor with hot sulfur dixoide-containing gases from the digesters, liquor recovery, and/or brownstock washing systems.

2. Loading of digesters with chips and liquor.

3. Cooking chips under regulated pressures, temperatures, and times using direct or indirect steam heat.

4. Relieving digester pressure, and recovery of spent gases and liquor [typically, gases are relieved through manifolds to the fresh liquor fortification system; liquor is either concentrated in steam-heated evaporators and used to make saleable by-products (either yeast or alcohol), or burned to produce heat or recover the base].

5. Pulp washing (in-digester, vacuum- or pressurized-drum, and extraction-belt type washers).

There are considerable variabilities in this type of operation throughout the industry. Many variations occur in types of sulfite pulping liquor, equipment for liquor preparation, chip cooking, chemical recovery, pulp washing and pulp mill layout and staffing. Because staffing arrangements in this operation are dissimilar thoughout the industry, job categories and descriptions are summarized below for three variations of this process.

In the first variation, the cook and assistant cook are equally involved in all phases of the digestion process. They control and monitor the process from a control room but are freqently near digesters to conduct liquor tests, load the digesters and operate manual and semiautomatic process equipment. Approximately 25% of their shift is spent in the process area. Liquor preparation, gas and liquor recovery and brownstock washing operations are all conducted by other workers.

In the second staffing arrangement the three-man staff operates an automated neutral sulfite semichemical pulping process and an adjoining kraft process. The operator is responsible for this highly variable work routine. Two assistant operators service the washer lines, adjust and inspect process equipment, take tank measurements, clean stock spills and perform general cleanups of process areas. The operator is in the process area about 30% of the shift, whereas the assistant operators work 50% to 70% of the time in the process area.

In the third staffing arrangement a chief operator monitors and adjusts the pulping process from a control room and directs two assistants. The assistants load five digesters, monitor cooking conditions, wash the cooked pulp while it is in the digesters and pump it into the brownstock pits. The assitants are in the processing area about 75% of their shift and the chief operator is in the area about 20% of this time.

During the NIOSH survey of this type operation, personal exposure monitoring for sulfur dioxide was conducted only for the first staffing arrangement. The results are presented in Table 73. Calculated TWA exposure for the cook and assistant cook were well below the OSHA PEL of 5 ppm. Samples collected with workers outside the control room were variable and ranged from 0.4 ppm to 5 ppm. Samples collected from the control room ranged from 0.5 to 0.6 ppm for the majority of each shift.

Table 73 PERSONAL AND AREA AIR MONITORING DATA FOR SULFUR DIOXIDE IN SULFITE PULPING

Job Category/Location	Concentration (ppm) Range	Mean
Cook[1]	0.4-3.6	2.2
Assistant Cook[1]	0.5-6.1	2.0
Area Samples		
Control Room	0.5-0.6	0.56
Near Digesters	0.5-25	12.8
Above Digesters	0.5- 100	50
Stock Washer Area[2]	1	1
Washer Filter Tank Area[2]	0.5	0.5
Blow Tank Vent[2]	12	12

[1] Personal samples taken when workers exited control rooms to perform tasks in processing areas.

[2] One sample only.

Samples taken near digesters showed high variability and ranged to 100 ppm directly above an open digester during loading. Readings taken at various work place locations indicated sulfur dioxide levels usually below 0.5 ppm, where continuous digesters are closed and alkaline sulfite liquor contains little free sulfur dioxide.

For the first staffing arrangement, low worker exposure to sulfur dioxide occurs primarily because of worker isolation in the control room (75% of the shift). Although the control room is not ventilated, the enclosure prevents excessive contamination, except during major process upsets. Sulfur dioxide levels in the work place are largely a result of emissions when the digesters are open for loading. Additional factors or systems which may assist in minimizing worker exposure are:

- An almost totally closed process, except during the digester loading operations.

- Digester relief gases are piped to recovery tower.

- The liquor blow and stock tanks are vented into an over gas system that leads to a separate absorption tower.

Worker exposures, as indicated by area sampling, for the second staffing arrangement are low primarily because the cooking process is totally closed and continuous and the digestion chemistry (alkaline sulfite) minimizes free sulfur dioxide generation. In addition, the brownstock washers are hooded and well ventilated.

Although no personal exposure samples were taken for the third staffing arrangement, area samples indicated sulfur dioxide concentrations on the digester operating floor (within 15 feet of the digesters) ranged from 1 ppm to over 10 ppm and varied according to the loading and empyting cycles of the nearby digester. Results of breathing zone samples taken near the digester revealed periodic exposure of up to 50 ppm.

High exposure on the digester operating floor for the third staffing arrangement may be attributed to the following factors:

- The general lack of process automation which necessitates two workers remaining on the operating floor in excess of 75% of their shifts.

- The ineffectiveness of the respirator program (the use of respirators is acceptable as a permanent control in Germany).

- The poor capture of sulfur dioxide (escaping through open digester tops during unloading and loading) by the loading cap exhaust system.

- No general ventilation of the digester operating floor.

Bleach Chemical Handling and Preparation Operations

Bleach chemical handling and preparation operations involve equipment and operating staffs to unload, store, dilute and/or prepare various bleaching chemicals. These operations can include:

- Liquid chlorine unloading and vaporization in steam-heated vaporizers.

- Caustic soda unloading and dilution.

- Hypochlorite solution preparation using chlorine gas and caustic soda.

- Chlorine dioxide solution preparation using a one- or two-stage reactor and a one- or two-stage gas absorption tower.

- Miscellaneous handling systems for chemicals such as sulfur dioxide, sulfuric acid, sodium chlorate, salt, and methanol. These chemicals are used primarily in the on-site generation of chlorine dioxide gas.

The complexity, size, degree of automation and location of equipment determine the number of required workers and tasks they perform. Specific staffing arrangements and worker assignments can be distributed among the five following major work tasks:

- Equipment monitoring and control.
- Equipment inspecting and manual adjustments.
- Unloading of incoming chemicals.
- Housekeeping and spill cleanups.
- Process quality control sampling and testing.

The operator, assistant, equipment tender, helper/tester, utility worker and unloader are job titles which share in the five areas of responsibility mentioned above. The operator is solely responsible for equipment monitoring and control and may be assisted in equipment inspection and manual adjustment by equipment tenders or assistant operators. Chemical unloading is strictly the responsibility of utility workers, unloaders, and helpers, although equipment tenders and operators perform this duty in small operations. Quality control sampling and testing is performed primarily by helpers/testers and assistant operators. Housekeeping and spill cleanup is a utility role although unloaders and assistant operators may be involved in this activity.

The primary air contaminants associated with bleach chemical handling and preparation operations are chlorine and chlorine dioxide. Extensive personal and area monitoring samples were collected for these contaminants during the NIOSH survey of such an operation as shown in Table 6.21. Minor potential work place contaminants for which no data is available include caustic mist, sulfur dioxide, sulfuric acid, methanol and sodium chlorate.

The personal monitoring data indicate that worker exposures are normally restricted to chlorine dioxide (potentially containing indeterminate amounts of chlorine) released during collection of some chlorine dioxide generator quality control samples (absorber, spent acid, and storage tank solutions). The exposures are of less than fifteen minutes duration and are controllable by: 1) locating sampling points outside or within small enclosures having some ventilation and flushable drains; 2) using respirators; and 3) training workers in better collection practices (standing upwind, using water to quickly flush the solutions into nearby drains, and standing away from sampling lines during initial flushing).

Table 74 PERSONAL AND AREA AIR MONITORING DATA FOR CHLORINE/CHLORINE DIOXIDE IN BLEACH CHEMICAL HANDLING AND PREPARATION FACILITIES

Job Title or Task	Concentration (ppm)	
	Range	Mean
ClO_2 Generator Tester	0.01-0.13	0.06
Chemical Handling Tester[2]	0.05-5.53	0.63
Manual Preparation of Hypochlorite	All 0.05	0.05
Tester of Hypo System	All 0.05	0.05
Area Samples		
ClO_2 Generator Areas	0.05-2.0	0.76
Control Rooms/Buildings	0-2.0	0.36
Vaporizer Tank Areas	0.05-0.3	0.12
Hypo Prep Areas	0.03-0.5	0.12

[1] All concentrations are reported as ppm chlorine, but some samples were collected in areas where chlorine dioxide was the sole concurrent contaminant. The sampling methods respond positively to this contaminant, but at unknown sensitivity; hence, preclude accurate analysis.

[2] Chemical handling and testing tasks were concurrently performed during some sampling periods.

Area monitoring data from inside a normally unoccupied generator building indicates other intermittant work place contamination and potential excessive exposure conditions occur. Unidentified generator leaks and brief direct chlorine dioxide emissions are associated with generator startup, shutdown, or process changes. Reactor puffs (explosions) relieved through a safety valve, sewer off-gasing when weak absorber solution is wasted, leaking seals or gaskets in gas or solution pipelines, or poor operation of the generator gas absorption tower cause high local chlorine dioxide concentrations. Exhaust hoods over reactor safety relief valves, restricted building entries, and general building ventilation are used to control potential exposures when these conditions exist. However, good process monitoring and control, equipment inspections, preventive maintenance, and locating and controlling specific emissions points (sewer and equipment vents) are equally important.

Liquid chlorine unloading equipment and gaseous chlorine preparation and distribution systems (vaporizers, hypochlorite reactors, and piping networks) should be completely closed and equipped with emergency gas expansion, pressure relief, and blowdown systems (eductors, air purge lines, and caustic tanks). Other controls used to reduce or warn of leaks and upsets and to insure protection of personnel include: process monitoring and alarm systems, preventive maintenance, respiratory protection (some northern mills require workers and visitors to carry respirators in designated areas), chlorine air monitoring and alarm systems, emergency escape and response plans, restricted building entries, special worker training, equipment isolation, and general ventilation.

General types of worker exposure control in this operation include:

- Process isolation - outside equipment or equipment located in isolated, unoccupied buildings.
- Local ventilation for chlorine dioxide generator.
- General ventilation (including natural ventilation of equipment located outside).
- Process characteristics - the close nature of most equipment; process automation, monitoring and control systems and alarms.
- Respiratory protection.
- Air monitoring systems.
- Worker isolation through use of control rooms.

These conditions result in few potential sources of work place contamination except as a result of an unusual upset or leak, or from a process startup/shutdown. Examples of such conditions would include an excessive chlorine gas pressure, a leaking chlorine unloading line, high vaporizer temperature and startup or shutdown of a chlorine dixoide generator.

Multistage Pulp Bleaching

This pulp whitening process is achieved by selectively treating the pulp with certain chemicals in three or more distinct stages. The major stages and chemicals include:

- Chlorination with chlorine gas.
- Alkaline extraction with sodium hydroxide solution.
- Hypochlorite treatment with sodium or calcium hypochlorite solution.
- Chlorine dioxide treatment with chilled solution of chlorine dioxide.

Minor stages, or bleach processes commonly used to brighten mechanical pulp to low or moderate levels include:

- Treatment with sodium or hydrogen perioxide solution.
- Destruction of residual chlorine dioxide and/or reduction of pulp pH using sulfur dioxide gas or solution.

- Single or double stage bleaching with sodium borohydride, or sodium or zinc hydrosulfite solutions.

Staffing arrangements depend on process size, degree of automation, plant layout and equipment, and the integration of bleach chemical handling and preparation operations. The four major task assignments performed for such an operation are:

- Process monitoring and control.

- Manual operation and adjustment of equipment, or inspections.

- Process quality control sampling and testing.

- Housekeeping and spill cleanup.

While the operator is solely responsible for process monitoring and control he is also assisted by equipment tenders and helpers for equipment inspection and operation. Quality control testing is performed primarily by helpers, although assistant operators are also assigned this task area. Housekeeping and spill cleanup are usually performed by utility workers, although operators and assistant operators may perform this duty in small operations. The total number of production workers for such an operation ranges from two to five.

The primary contaminants of concern to workers in multistage bleach plants are chlorine and chlorine dioxide. Personal and area monitoring data collected during the NIOSH survey of several such operations for these contaminants are presented in Table 75. Other minor potential work place contaminants for which no data are available include caustic mist from alkaline extraction stages and sulfur dioxide from dechlorinating/pH adjustment agents.

Personal air sample results indicate low risk of overexposure during normal process operations with proper control of the chlorination and chlorine dioxide stages. Area monitoring data indicate increased work place contamination during process alternations, upsets and startups or shutdowns.

General survey data (monitoring results and technical discussions performed by NIOSH) indicate that the following are fundamental to eliminating chlorine off-gasing and controlling release to the work place:

- Accurate chlorine gas dosage control in first stage bleaching.

- Proper performance of washer exhaust hoods.

- Good overall process control.

Process and equipment characteristics may have equal importance. However, no definitive conclusions were made by NIOSH concerning the effectness of automated versus manual or semiautomated dosage control systems, varieties of automated control systems, design and performance of washer hood or other

Table 75 PERSONAL AND AREA AIR MONITORING DATA FOR CHLORINE/CHLORINE DIOXIDE EXPOSURE IN PULP BLEACHING FACILITIES[1]

Job Title or Task	Concentration (ppm)	
	Range	Mean
Equipment Inspection	0.015	0.015
Utility Worker	0.05-0.20	0.10
Bleach Plant and Chemical Handling Tester[2]	0.05-0.78	0.19
Bleach Plant Tester	0.05-0.86	0.10
Area Samples		
Control Rooms	0.05-1.85	0.17
Washer Floors	0.05-1.27	0.28
Hypo Cell Areas	0.05-0.3	0.16
Cl_2 Washer Area	0.05-1.0	0.22
Caustic Washer Area	0.1	0.1
Inside Cl_2 Hood	10	10
Inside Hypo Hood	0.1	0.1
Inside ClO_2 Hood	0.1	0.1

[1] All concentrations are reported as ppm chlorine, but some samples were collected in areas where chlorine dioxide was the sole concurrent contaminant. The sampling methods respond positively to this contaminant, but at unknown sensitivity; hence, preclude accurate analysis.

[2] Chemical handling testing tasks were concurrently performed during some sampling periods.

equipment designs. The general types of worker exposure controls which vary among multistage mills include:

- Process characteristics and control systems; closed and/or automated equipment; equipment isolation; and outside bleach towers, chlorine/chlorine dioxide injectors, mixers and dosage control systems.
- Local and general ventilation - washer hoods, atmospheric bleach tower and filtrate tank vents; forced ventilation of bleached towers and filtrate tanks with and without exhaust scrubbing.
- Worker isolation in control rooms.
- Respirator protection.
- Chlorine air monitoring and alarm systems.
- Worker training, education and other special practices.

Mechanical Pulping

Mechanical pulps are produced by grinding wet, debarked logs, by separating wood fibers from chips in refiners, or by softening wood chips with steam, followed by mechanical refining (TPM). In the refining process, chips are attrited by passage between two disks having alternating bars and depressions on the surfaces; the disks are rotated in opposite directions by directly connected loaders.

Job categories and responsibilities vary considerably throughout the industry for this type of operation and depend on the degree of process automation, size and complexity of the mill.

Table 76 presents general job categories and the estimated number of workers per shift for mechanical pulping process workers. Also shown in this table are personal and area air monitoring data obtained during the NIOSH survey of mechanical pulping processes.

Operators, helpers/testers and utility workers are three general job categories which can be described for mechanical pulping. Operators have primary responsibility for operating and monitoring the process and assume responsibility for startups and shutdowns. The operator may spend from 40% to 95% of his shift time in a control room. The remaining portion of his time is spent for only miscellaneous tasks or equipment inspections. Helpers assist the operator and perform such duties as process inspections, collecting test stock samples, transporting logs to grinders and serving as foremen. Depending on the specific nature of their responsibilities and the type and complexity of the operation, helpers may spend from 0% to 95% of their time in a control room. Utility workers are primarily responsible for housekeeping and assist the operators as needed. A utility worker may spend from 15% to 75% of his time in a control room.

Table 76 PERSONAL AND AREA AIR MONITORING DATA FOR MECHANICAL PULPING (mg/m^3)

Job Category	Est. No. of Workers/Shift	Nuisance Dust		Turpenes		Total Hydrocarbons		Resin Acids		Alcohols		Phenols		Ketones	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Operator	1-8	0.01-0.20	0.10	<0.02-0.04	<0.03	All	<0.04								
Helper/Tester	1-5	0.05-0.13	0.09												
Utility	1-2	0.30-0.50	0.40												
Area Samples															
Chip Washing/Feeding		0.04-0.16	0.10												
TMP Process Areas				0.02-0.15	0.07			0.70-33.0	20.9	0.02-0.18	0.07	1.7	1.7		
Mechanical Grinding Areas				<0.02-0.06	<0.04	0.02-0.06	0.04			All	<0.04				
Mechanical Refining Areas				<0.01-0.49	<0.10	All	<0.03	All	<0.03	All	<0.03	All	<0.03	All	<0.03
Decker Areas				<0.01-1.30	<0.45	All	<0.03	All	<0.03	All	<0.03	All	<0.03	<0.01-0.05	0.03

Personal and area air sampling data developed from the NIOSH survey of mechanical pulping showed total dust exposures for all job categories in air samples to be well below the OSHA PEL of 15 mg/m^3 total nuisance dust. Work place concentrations of turpentine, turpenes, total hydrocarbons, alcohols, ketones and phenols are shown to be very low or nondetectable. Appreciable levels of resin acids, however, were detected in a TMP process area.

Process characteristics and other factors that are known to prevent significant worker exposure in mechanical pulping include:

- No chemicals are used; potential air contaminants are restricted to wood dust and volatile wood constituents.
- Processes are largely closed, with wood chips and roundwood being handled wet, minimizing dust generation.
- Many mechanical pulping processes are automated and workers remain mostly in control rooms or acoustic enclosures.
- Good housekeeping.

Papermaking Operations

The number of workers involved with papermaking operations varies considerably, depending on factors such as:

- Number and location of paper machines, coaters and slitters/rewinders.
- Nature and complexity of the wet-end operations.
- Nature, number and complexity of the dry-end operations.
- Complexity, speed and automation of equipment.

Table 77 presents a summary of job categories and the estimated number of workers per shift, per machine typically involved with papermaking operations. Included in this table is a summary of air monitoring results of personal samples taken during the NIOSH survey of papermaking operations.

In the following discussion, each of the general process operations and general job categories will be described in terms of potential work place hazards, NIOSH air monitoring results and description of worker exposure controls observed during the NIOSH survey.

Wet End Additives and Stock Preparation

Preparing pulp stock and wet-end additives typically include dissolving dry pulp; beating, refining, thickening, cleaning, and blending pulps; preparing wet-end additives such as sizes, fillers, and covering agents; and blending and mixing all ingredients to produce the final machine furnish.

Table 77 GENERAL CREWING PATTERNS AND EXPOSURE DURING PAPERMAKING OPERATIONS

General Process Operations	General Job Categories	Est. No. Workers (Per Machine)	Formaldehyde (ppm)		Nuisance Dust (mg/m^3)		Sodium Hydroxide (mg/m^3)		Ammonia (ppm)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean
Wet-End Additives and Stock Preparation	Operator (Beater Man)	1	0.01-1.76	0.18					0.5-3.5	1.2
	Helper or Assistant	1-2			0.3-3.5[1]	1.1[1]				
	Utility	0-1								
Coating Preparation	Operator	1	0.03-0.09	0.07	0.2-0.6	0.4	All	<0.06		
	Assistant or Helper	1-2			2.4-8.5[2]	5.1[2]				
	Utility	0-1								
Papermachine Wet-End	Machine Tender	1								
	Assistant or Helper	0-1								
	Utility	0-1								
Papermachine Dry-End	Back Tender	1			0.3[3]					
	Slitter/Winder Operator (3rd hand)	1			0.3-10.0	5.1				
	Assistants, Helpers or 4th/5th Hands	1-3			0.3-9.1	2.7				
	Utility	0-2								
	Coater Operator (If there is on-machine coating)	1								
Off-Machine Coating	Operator	1	0.02-0.27	0.15						
	Assistant or Helper	1	0.17-0.47	0.24						
	Utility	0-2	0.08[3]							

1 Bulk Material handling
2 Bulk Plant Opertion
3 One Sample Only

Coating formulations and wet-end additives vary somewhat among production lines. Typically, these raw materials include:

- Clay
- Starch
- Titanium Dioxide
- Ammonia
- Water
- Calcium Carbonate
- Latex
- Melamine-Formaldehyde Resins
- Calcium Stearate
- Optical Brighteners
- Plastic Pigments
- Carboxylated Methyl Cellulose

Very small quantities of tinting agents, defoamers and dispersants may also be added to each formulation. If a batch is required to be held for a significant period of time, a small amount of slimicide must be added.

During these operations, bulk material handling employees are exposed to nuisance, airborne particulate matter, including starch, clay, titanium dioxide and calcium carbonate. The primary air contaminants to which the operators are exposed include ammonia (used intermittently) and formaldehyde (melamine-formaldehyde resin contains 1% or less free formaldehyde). The preservatives, tinting agents, defoamers, dispersants and other minor ingredients are used infrequently and in small quantities. Depending on the intended use of the paper, wet-end additives and coating components vary widely.

NIOSH air monitoring results for such an operation (Table 77) relied on total particulate samples to determine exposures in the bulk handling of dry materials. The highest value measured (3.5 mg/m^3) was well below the OSHA PEL of 15 mg/m^3 of total nuisance dust. There does not appear to be any significant variation in results among employees preparing wet-end additive formulations and those unloading bulk raw materials on receiving docks. Higher values are probably attributed to abnormal dust generated while bag filters on vacuum unloader receivers are being changed.

Formaldehyde samples collected by NIOSH were all below the 3 ppm TWA OSHA PEL limit. Short term personal samples were also collected for ammonia to estimate exposures when this compound was added to certain formulations. Employee exposures to ammonia were found to be well below the OSHA PEL of 50 ppm to TWA.

Following is a list of significant occupational exposure control practices observed by NIOSH during the survey for this type of operation:

- Bulk quantities of clay, starch, and calcium carbonate are unloaded with automated and closed vacuum unloader and pneumatic conveyance systems (to roof-mounted storage silos with exhaust air bag filters).
- Closed auger system to transfer clay and crystalline calcium carbonate to mixing tanks.
- Closed auger system to automatically transfer starch to makedown tank (tank has auto-replenisher which continuously maintains proper level of starch slurry).
- Good housekeeping and work practices for handling bags of titanium dioxide.
- Unloading dock and mixing areas are cleaned each shift to minimize secondary dust generation sources.
- Closed screw-conveyor transfer system for amorphous calcium carbonate in color room with effective recirculating dust collection system (with exhaust air cyclone and bag filter).
- Process factors - melamine-formaldehyde contains less than 1% free formaldehyde; dumping resin takes less than 5 minutes; infrequent ammonia use involves small quantities.

- Local exhaust hood over blade-coating formulation screen.

- Storage tank exhaust system.

Coating Preparation

On and off machine coating formulations are prepared in a separate area or facility, but may be integrated into the area used to prepare wet-end additives. The coating operation begins with the preparation of a number of different coating formulations in a large mixing tank. A typical batch may contain some or all of the following ingredients:

- Clay
- Starch
- Titanium Dioxide
- Calcium Stearate
- Ammonia
- Wet Strength Resin
- Dispersant
- Defoamer
- Antimicrobial Agent
- Water
- Sodium Hydroxide
- Soda Ash
- Calcium Carbonate
- Latex

Small quantities of slimicides, tinting agents, defoamers and dispersants may be added to each batch. Four employees are necessary to operate this process as observed during the NIOSH survey.

The major potential work place contaminants in this operation are nuisance dust, such as starch, clay, titanium dioxide, and soda ash. There is a much lower potential for exposure to sodium hydroxide mist. Preservatives, tinting agents, defoamers, and other minor ingredients are generally used in too small a quantity to present a problem. Other major work place contaminant hazards are formaldehye and ammonia. Free formaldehyde (less than 1.5%) is contained in the wet-strength resins, made up of either urea-formadehyde or melamine-formaldehyde. Ammonia-containing ingredients are used infrequently. The latex is a styrene-based polymer containing less than 0.05% free stryene.

Personal samples taken during the NIOSH survey for formaldehyde, nuisance dust and sodium hydroxide are shown in Table 77. Since the operator is responsible for loading the wet-strength resin, operating the mixer, and cleaning the screens, his potential for exposure is much greater than the other employees. The measured TWA exposures (0.09 ppm and 0.03 ppm) were less than 3% of the OSHA PEL of 3 ppm TWA. NIOSH judged that the TWA exposure of the operator or other employees rarely, if ever, exceeds permissible levels for formaldehyde. Sodium hydroxide was not detected on any personal samples. Since the detection limits (0.04 to 0.06 mg/m^3) are well below the OSHA PEL of 2 mg/m^3, it is evident that these workers are not exposed to excessive quantities of sodium hydroxide.

Coating preparation operators' exposure to nuisance dust was well below the OSHA PEL of 15 mg/m^3 for total nuisance dust. Measured TWA exposures for the bulk plant operator were much higher, ranging from 2.2 to 3.5 mg/m^3 but still well below the OSHA PEL. The higher exposures for this worker are attributable to the unloading of dry, bulk quantity raw materials, and the manual handling of bagged starch at the wet-end starch operation.

During the NIOSH survey of this type of operation, the following worker exposure control practices were observed:

- Local exhaust hood for coating formulation mix tank.
- Exhaust hoods and recirculating dust collection system (cyclone and bag filter) for starch blending tanks and wet-end starch mixing tank.
- Local exhaust for each of 6 main mill starch blending tanks.
- Five roof exhaust fans for bulk plant (27,800 cfm; 6-10 air changes/hour).
- Three roof exhaust fans for main mill (48,000 cfm; 6-10 air changes/hour).
- Process factors - many bulk materials purchased as slurries; clay and starch are unloaded and transferred with automated and closed (pneumatic or auger) systems; minimal handling of raw materials; sodium hydroxide purchased as a liquid.
- Housekeeping

The only excessively dusty operation observed was the manual addition of bagged starch at the wet-end starch mixing tank. During the survey it was noted that such an operation can be modified to allow the starch to be augered from the storage silos directly into the mixing tanks.

Two case studies are presented later in this section which give additional information on this type of operation. These studies are:

- Chemical exposure during paper coating preparation.
- Exposure to nuisance and starch dust at a corrugated paper finisher.

Paper Machine Wet-End

During the wet-end papermaking operations, web forming and water removal by suction and/or pressing are conducted on a fourdrinier or cylinder machine. The number of workers attending such an operation is estimated in Table 77 and tends to vary throughout the industry with the complexity, speed and automation of the equipment. Crewing patterns for other machine types such as rotoformers and twin wire machines vary in the same way.

Since this operation was not observed during the NIOSH survey, the reader is referred to Mist and Gas Exposure at a Paper Machine for a description and case study of such an operation.

Paper Machine Dry-End

Dry-end papermaking operations involve web drying, on-machine coating and drying, on-machine calender, reeling, slitting/rewinding, quality control testing and packaging and shipping. For each type of paper machine, dry-end operations are similar. During such an operation, the back tender has primary responsibility, for drying, calendering, and reeling operations. The third-hand's duties are primarily to operate the winder and make the finished roles for the wrapping area. Although much of his time may be spent at the winder control counsel overseeing the operation, the third-hand conducts most of the area blowdown operation. He also adjusts the slitter blades as necessary. The fourth and fifth-hands conduct various tasks including removing broke, threading paper, preparing cores and assisting with the area blowdown.

Workers at the dry-end of paper machines are potentially exposed to paper dust, which is considered to be a nuisance dust with an OSHA 8-hour TWA permissible exposure limit of 15 mg/m^3.

During the NIOSH survey of such an operation, it was observed that dry-end exposure to nuisance dust varied according to paper type, with production and handling of tissue paper and paper towels producing greater quantities of dust than newsprint. Despite this high variability, measured exposures were well below the OSHA TWA PEL for total nuisance dust in the blowdown operation, which is conducted at least once during each shift by third-hands with fouth-hands assisting. This operation consists of using a compressed air line and a hand-held jet nozzle to blow settled dust from all machine equipment and work surfaces to reduce the fire hazard of dust accumulations on rotating or heated equipment. Workers performing this operation wear dust masks and attempt to blow all dust towards central broke recovery systems. Other dry-end employees usually must stop work and stand in unaffected areas during this operation. Dust exposure concentrations of 8-10 mg/m^3 were noted for this operation during the NIOSH survey. Other minor sources of dust were noted at the slitters of each machine and whenever the wet breaks and must be rethreaded into a machine.

For the control of work place exposures, the following worker exposure control practices were observed by NIOSH:

- General roof exhaust fans.
- Unwinding station canopy hood.
- Ejector-type twin blower system for pneumatic conveyance of trim from slitters.
- Dust masks.
- Machine "blowdowns" each shift to remove accumulated paper dust.

Later in this section, six case studies are presented which provide additional detailed information on worker exposures during dry-end operations. These case studies are:

- Dust, smoke, and solvent vapor exposure at a newsprint finisher.
- Exposure to nuisance and starch dust at a corrugated paper finisher.
- Asbestos dust exposure during corrugated paper finishing.
- Paper dust expsoure at a corrugated paper cutter.
- Silica, asbestos, formaldehyde, and asphalt exposure at a building paper plant.
- Asphalt (hydrocarbons) and dust (silica) exposure at a roofing felt plant.

Off-Machine Coating

The NIOSH survey observed off-machine coating on a 165-inch bench Beloit off-machine coater. In this operation the coating is applied by passing the paper through a coating trough that is continuously replenished from the holding tanks. Although a number of different coating formulations may be utilized, a typical formulation may contain some or all the following ingredients:

- Clay
- Starch
- Titanium Dioxide
- Calcium Stearate
- Ammonia
- Wet-Strength Resin
- Dispersant
- Defoamer
- Antimicrobial Agent
- Water

Following the application of the coating formulation, the paper is dryed in a gas-fired, infrared heater and a series of steam heated drums. After passing through the second stage dryer, the paper is rewound into a coated roll of paper.

During this procedure, the operator is responsible for monitoring and recording process parameters, helping the utility person load or unload rolls of coated paper, and checking the quality of the coated paper. During upsets, his duties include cleaning the dryer section drums and controling the rethreading operation to get the coater back on line. The responsibilities of assistants include removing broke from the coater area and assisting the operator as required. Utility personnel are used to remove coated rolls of paper from the line, add empty rolls and remove broke from the area.

During off-machine coating, workers are potentially exposed to formaldehyde and ammonia (when used). At the off-machine coater, small quantities of formaldehyde can be released from the coating troughs, with the majority being driven off at the dryer section. Because employees may be relatively isolated from the coater during normal operations, there is little potential of exposure. However, during upsets, when employees are cleaning equipment and rethreading the coater, the potential for exposure is increased.

During the NIOSH survey, very low TWA exposures were observed for the coater operator. TWA exposures for the assistant operator also reflected very low formaldehyde exposure, with a similar lack of significant exposure for the utility person.

It was also noted during the survey that employee exposures to formaldehyde were very low during stable operating conditions. During upsets however, when employees are required to be in and closely around the coater, the potential for significant short term exposures is increased (one area sample indicated a high of 2.27 ppm). Unless there are problems with air conditioning and turn over in the dryer hood (creating dead air spots where formaldehyde could accumulate), ceiling exposures should remain well below the OSHA PEL of 5 ppm.

Listed below are worker exposure control practices which were observed for off-machine coating operations during the NIOSH survey.

- Local exhaust hood for coating formulation mix tank.
- Large open hood over first and second stage dryers, coating stations, and infrared heaters of an off-mahcine paper coater.
- Good general ventilation of coater area (heated supply air fan and 2 floor-mounted man-coolers).

Later in this section, four case studies are presented which provide additional detailed information on worker exposure during off-machine coating operations. These case studies are:

- Chemical vapor exposure in a kraft paper coating opertion.
- Solvent vapor and dust exposure in a paper coating operation.
- Silica, asbestos, formaldehyde, and ashphalt exposure at a building paper plant.
- Asphalt (hydrocarbons) and dust (silica) exposure at a roofing felt plant.

CASE STUDIES

A collection of 11 Health Hazard Evaluation (HHE) reports are reviewed in this section for their relevance to pulp and paper industry processes. These HHE's have resulted from field investigations of possible health hazards in the workplace by the Hazards Evaluations and Technical Assistance Branch of NIOSH. Such investigations are conducted under the authorization of the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the work place has potentially toxic effects in concentrations used or found.

The review of these HHE's has provided detailed information on the number of workers and their activities associated with process and waste chemicals, near-source chemical concentrations, routes and effects of exposure during worker activities, the use and misuse of protective equipment and procedures, in addition to specific conclusions and recommendations to control occupational health hazards and prevent related trauma or disease. These reviews, which have been developed to illustrate these aspects of worker exposure, are presented for the following specified activities:

- Chemical exposure from a sulfite mill waste treatment plant
- Mist and gas exposure at a paper machine
- Chemical exposure during paper coating preparation
- Chemical vapor exposure in a kraft paper coating operation
- Solvent vapor and dust exposure in a paper coating (flocking) operation
- Dust, smoke, and solvent vapor exposure at a newsprint finisher
- Exposure to nuisance and starch dust at a corrugated paper finisher
- Asbestos dust exposure during corrugated paper finishing
- Paper dust exposure at a corrugated paper cutter
- Silica, asbestos, formaldehyde, and asphalt exposure at a building paper plant
- Asphalt (hydrocarbons) and dust (silica) exposure at a roofing felt plant

Chemical Exposure from a Sulfite Mill Waste Treatment Plant

NIOSH performed an investigation to determine whether employees working at a pulp/paper mill pollution plant were being exposed to substances that were causing sore throats, bronchitis and headaches (78). In this effort, an environmental and medical investigation was conducted to determine whether sludge and/or water treatment operations were exposing workers to significant concentrations of toxic vapors and gases.

Processing operations at the plant begin in the wood yard, with debarking and other pulp wood preparation, and proceed to sulfite pulp production and/or refined groundwood. Pulp is sent through washers to remove excess acids and is then screened, cleaned, thickened, and stored in tanks until further use. At the paper room, light-weight printing grade papers are manufactured.

Of particular importance at this mill is the secondary treatment pollution plant which is located southeast of the mill. Materials in slurry form are received at the treatment plant in a five million gallon clarifier. The clarifier, with a skimmer and rakecom system processes 30 million gallons of sludge per day. Solids removed from the bottom of the clarifier are conveyed to coil filters where they form sheets. The sludge sheets are then dissevered, conveyed to a press (1800 psi) to remove excess liquids, conveyed to the outside, loaded onto trucks and then hauled to a landfill. Liquids from the press as well as those from the clarifier are piped to a 10 acre lagoon site where ammonia is added for pH control. The liquids settle in the lagoon for 24 hours and are then treated for four to five days in an aeration pond. From the aeration pond all treated waters are pumped into a river.

The results of a long-term sampling program for sulfur dioxide, sulfuric acid mists, toluene and other organic and inorganic gas emissions are presented in Tables 78 and 79. Although levels of toxic exposure found at the Secondary Treatment Plant were within the current recommended (NIOSH) and legal (OSHA) standards, the potential for increased concentrations was thought to exist. One such area is the sludge loading space, where moist sludge, which gives off heat while accumulating, can ferment and thus emit potentially toxic gases and/or vapors (H_2S, SO_2, toluene, etc.). In addition, paper products run at the primary plant have different exposure potentials which may present increased risk problems. Variables influencing these risks include wind direction, temperature, humidity and product type.

NIOSH medical personnel interviewed seven men presently employed in the secondary treatment plant and three former drivers who discontinued working at the treatment plant because of various medical reasons. From these interviews, it was found that irritative symptoms such as sore throats were experienced by some of the waste treatment plant employees. Additionally, 2 employees who reported near syncopal episodes were performing duties which exposed them to increased H_2S levels. Frequent headaches were likely due to secondary and/or intermittent excessive H_2S exposure. The brochitic symptoms and sore throats were possibly exacerbated by H_2S as well as by chemical contaminants such as SO_2 which are reported to be occasionally carried by the wind to the waste treatment facility from the main plant. Skin rashes were potentially work related although none of the known chemical exposures were reported to cause a rash. The majority of employees agreed that fewer symptoms were being experienced at the time of the NIOSH visit and they felt this decrease in symptoms was due to the newly enacted practice of

Table 78 RESULTS OF AIR SAMPLES FOR INORGANIC GASES, TOLUENE AND TOTAL HYDROCARBONS

	Sample Type	Location	Concentration in parts of gas per million parts of air (ppm)	
Sulfur Dioxide	Personal	Clarifier Operator - take samples	Below limit of detection	
	Personal	Millwright (maintenance)	Below limit of detection	
	Personal	Operated front end loader	Below limit of detection	
	G. Area	Conveyor (above press)	Below limit of detection	
	G. Area	Conveyor (above press)	Below limit of detection	
Sulfuric Acid	G. Area	Conveyor (above press)	Below limit of detection	
Mists	--	Under rotary drier	Below limit of detection	
	--	---	Below limit of detection	
Organic Compounds	G. Area	Conveyor above hopper/press	Non detectable levels	
(Amines) including	G. Area	Conveyor above press	Non detectable levels	
Hydrogen Sulfide	G. Area	Operator Control room	Non detectable levels	
			Toluene	Total Hydrocarbons
Hydrocarbons	Personal	Operator (takes samples)	.08 ppm	4.1 ppm
Hydrocarbons	Personal	Millwright (maintenance)	.10 ppm	11.0 ppm
Hydrocarbons	Personal	Operator front end loader	.08 ppm	0.2 ppm
Hydrocarbons	Damaged		NA	8.6 ppm
Hydrocarbons	G. Area	1st Floor under Rotary Drier	.03 ppm	5.71 ppm

Table 79 RESULTS OF AIR SAMPLES FOR VARIOUS GASES

	Concentration (ppm)						
Location	CO	Cl_2	CO_2	NO_x	SO_2	NH_3	H_2S
Above press	5.0	ND	1000	ND	ND	ND	ND
Outside near sludge pile	5.0	ND	1000	ND	0.2	ND	ND
Inside	ND	--	1000	ND	ND	--	ND
Outside near loading area	ND	--	1000	ND	ND	--	ND
Inside loader cab	ND	--	1000	ND	--	--	ND
Outside near sludge pile	ND	--	1000	ND	ND	--	ND
2nd Floor above press	ND	ND	1000	ND	ND	ND	1.0

- Personal emergency escape units should be provided to the drivers and other heavy equipment operators who load or unload sludge materials. In addition operators inside the plant should be equipped with personal protective devices to be donned in emergency situations. Training in proper use and maintenance of these units should be provided to each pollution plant employee.

adding more lime to the wastewater prior to clarifier entry. The increased alkalinity appeared to decrease the formation of hydrogen sulfide.

As a result of this investigation the following recommendations were made:

- The application of increased lime materials for purification pruposes should be continued since this technique appears to decrease H_2S formation.

- Moisture and heat given off while the sludge accumulates causes fermentation to take place thus releasing toxic gases and vapors. Therefore, the pressed sludge materials should be removed from the plant area every two to three days rather than being allowed to accumulate.

- An H_2S meter along with an audible alarm system should be installed in the pressed sludge piling area. A probe from this meter should be located near the western wall along-side the sludge pile and an alarm should be set (when 10 ppm is detected) to sound inside the control room as well as the outside loading area. The meter should be observed regularly and calibrated at least monthly.

- The pollution plant's H_2S emergency procedure memo dated May 1978, should be updated to include donning of respirators when 10 ppm H_2S levels are indicated by the H_2S meter and/or alarm.

- Paper products being processed at the primary plant should be correlated with "worst conditions" situations found at the pollution plant in an effort to determine if particular paper and pulping operations are responsible for increased gas and/or vapor exposure problems. With such data, a written safety action plan could be incorporated into the employee's work schedule to help reduce the potential for unhealthy work conditions.

Mist and Gas Exposure at a Paper Machine

In an HHE involving only a paper machine, NIOSH performed an investigation to determine if vocal cord nodules experienced by two of four paper machine tenders were caused by the exposure to a combination of chemicals in a high noise work enviornment (79). This investigation took place at a pulp and paper mill that produces paper for newsprint.

During pulp production at this plant, a variety of chemical compounds are added. Some of these are still present when the pulp reaches the paper machine. Several additional chemicals are added just before the pulp passes through the paper machine, such as slime control agents, brighteners and, pH control chemicals. Some of the chemicals used are sulfuric acid, sulfur dioxide, trisodium phosphate, aluminum sulfate, sodium mercaptobenzothiazole, triphenylmethane dye, dithiocarbamates, pentachlorophenols, pentachloropheates, n-alkyl dimethylbenzyl ammonium chloride and others.

The pulp solution (approximately 3% pulp) enters the headbox of the paper machine and is flowed on a high speed moving screen. In this section (the fourdriner) the water is removed by suction. Mists, vapors and aerosols are released due to the high speed of the moving screen. Some mist is also sprayed out the sides in several places, these is no local exhaust ventilaton on this section; however, there are ceiling fans about 30 ft above the fourdriner.

The flattened and fleted pulp then passes over a heavy woolen blanket between press rollers where additional water is removed. From there, it proceeds to the dryer section where the paper is dried by passing it over a series of steam heated cylinders. The dryer section is enclosed with a ventilating hood where the moist air is removed. After drying, the paper receives its finish between the rollers of the calander and is wound up on a reel. The headbox, fourdriner and press section comprise the wet end and the remainder the dry end of the process.

On each shift there are six workers on the machine. They are the utility man, 5th hand, 4th hand, 3rd hand, back tender and machine tender. The machine tender works at the wet end and the other 5 work at the dry end. The machine tender is the top job with progression through the jobs on a seniority basis. There are four crews that rotate shifts to cover this 24 hour, 7 day a week operation.

At the wet end of the paper machine, there is a series of control consoles and a control shack. A machine tender works at the control panels, makes periodic inspections of the entire wet section, makes repairs during breakdowns and spends the extra time in the control shack. He is exposed to the mists, vapors and gases that are released and to high noise. The dry end is operated by five workers whose exposure consists mainly of high noise.

In a medical review, machine tenders stated that at various times they may experience sore throats, irritaiton of the eyes, nose and throat, buring eyes, irritation of the skin and headaches which are not present (or clear up) when off the job for extended periods such as vacations. These symptoms can be caused by many of the chemicals added to the pulp. Although the airborne concentrations are low, operators often come in physical contact with mists, they have stated that the symptoms are more prevalent when the pH of the liquid is below 4-5.

Breathing zone and area samples were collected for sulfuric acid, sulfates, and phosphates. Sample results are shown in Table 80. The averge exposure of back tenders to sulfur dioxide was 0.02 ppm while the exposure to machine tenders was significantly higher at 0.11 ppm. All breathing zone samples were less than the sulfur dioxide criteria of 0.5 ppm. The machine tender's exposure was noted to vary depending on the amount of the time spent at different locations around the wet end of the machine. As seen in the results the area sample concentrations were as high as 0.95 ppm.

Machine tenders on one such machine had sulfuric acid exposures of 0.01 and 0.02 mg/m^3. This is 1 to 2% of the current standard. The highest area sample, which was collected in the mist on the north side walkway along the fourdrinier of one machine, was 0.6 mg/m^3. The back tender's breaching zone sulfuric acid samples were all less than 0.01 mg/m^3.

Table 80 SULFUR DIOXIDE, SULFURIC ACID AND PHOSPHATE AIR CONCENTRATIONS IN A PAPER MACHINE DEPARTMENT

Job or Area	Sulfur Dioxide ppm	Sulfates as Sulfuric Acid mg/m^3	Phosphates mg/m^3	Potential Noise Exposure, 8-hr TWA dBA
Machine Tender #1 Machine (BZ)	0.02	0.01	0.01	96
"	0.15	0.01	0.01	97
"	0.14	0.01	0.01	95.5
Machine Tender #2 Machine (BZ)	0.09	0.02	0.01	101
"	0.12	0.01	0.01	94
"	0.14	0.01	0.01	96.5
Back Tender #1 Machine (BZ)	0.03	0.01	0.01	96.5
"	0.04	0.01	0.01	95.5
"	0.02	0.01	0.01	95.5
Back Tender #2 Machine (BZ)	0.03	0.01	0.01	98
"	0.01	0.01	0.01	98.5
"	0.01	0.01	0.01	94.5
South Side of Wringer Roller #1 Machine (GA)	0.54	0.01	0.01	--
"	0.51	0.01	0.01	--
"	0.95	0.1	0.01	--
North Side #1 Paper Machine By Wire in the Mist (GA)	0.34	0.01	0.02	--
"	0.33	0.06	0.16	--
"	0.68	0.04	0.02	--
South Side by Rail-Side Silo & Wire (GA)	0.08	0.01	0.01	--
	0.12	0.02	0.01	--
"	0.15	0.01	0.01	--
Stock Prep Control Room (GA)	0.01	0.01	0.01	--
Inside Control Shack by Control Panels (GA)	--	--	--	73
Control Panel Area	0.16	0.01	0.01	97
"	0.13	0.01	0.01	96.5
"	0.12	0.01	0.01	--
So. Side #2 Machine Inside Hood 1st Deck, in the Mist (GA)	0.09	0.03	0.01	--
"	0.05	0.02	0.01	--

BZ - Breathing Zone Sample
GA - General Area Sample

All breathing zone and area samples for phosphates were less than 0.01 mg/m^3. Area samples collected in the mist on the north side walkway along the fourdrinier of one machine, however, were 0.02 and 0.16 mg/m^3. (There currently is not standard for phosphate or trisodium phosphate).

One of the other chemicals added to the pump were samples as they are added in small quantities and would not be detectable. This is shown by the bulk liquid samples taken at the side silo, which contained 360 mg of sulfates/liter while the majority of the airborne sulfate sample results were less than detectable limits. The bulk samples alos contained 10 to 20 mg of phosphates per liter and less than 0.001 mg of pentachlorophenates per liter.

Two machine tenders had surgery for vocal cord nodules. They were potentially exposed to 8-hour equivalent noise exposure levels of 94-110 dBA, during which time frequent communication by voice was required, with airborne concentrations of sulfuric acid mist, sulfur dioxide and other potential chemical irritants below the applicable standards. The machine tenders stated that at various times they experienced sor throat, irritation of eyes, nose and throat, buring eyes, irritations of the skin and headaches. NIOSH postulated that there may be a relationship between the development of vocal cord nodules and exposure to high noise levels and to irritant chemicals. This is based on a literature review showing that upper respiratory infection and high noise exposure results in the production of vocal cord nodules and the fact that the workers on the dry end of the paper machines do not develop nodules while exposed to the same noise levels but not to the upper respiratory irritants.

As a result of this investigation, NIOSH presented the following recommendations:

- Adverse health effects of eye, nose and throat irritaton appear to be more relevant when the pH of the pulp liquor is less than 4-5. Raising the pH above this level may be helpful.
- Use of an air supplied respirator or air cap that provides filtered air past the face could reduce the machine tenders' eye, nose and throat contact with chemical irritants.
- Since it appears that voice strain occurs during communica- tion in high noise areas, the use of a communication system involving a collar or throat microphone, a transmitter and a receiver built into ear muffs would permit the machine tender to talk in a normal voice and thus reduce the voice strain.
- Workers experiencing persistent hoarseness should have their vocal cords examined for nodules or other vocal cord abnormalities.

Chemical Exposure During Paper Coating Preparation

An HHE was performed in the coating preparation department of an integrated thermo-mechanical pulping process that manufactures printing paper (80). In this department, employees working with Metasol D3TA and DuStrypp (trade names) experienced eye and skin irritation.

Latex, Metasol D3TA and DuStrypp are added via a closed system to mixing vats containing a clay dispersion in the area where the complaints arose. This coating is then fed to the coating machines and applied to paper rolls. The final mix area contains five mixing vats approximately 8 ft. in diameter and 10-15 ft. deep. Each vat is equipped with a 1 ft. square hinged access port for collection of hourly quality control (Q.C.) samples. Vats operate at 140°F. Each "Coating Prep." Dept. crew consists of five employees working on a 7 day rotating shift basis, allowing three shift coverage and one crew off each day. Of the five employees, two work in the vat room while the other three work in an air conditioned computer room, or outside the building in the per-mix area.

Formal interviews with the union steward and several employees in the "Coating Prep." department and review of first aid records revealed that eye irritation is common to workers in the final mix area, where workers are required to collect samples from the mix tanks (screeners). Employees indicated that the irritation is worse in the winter months when the windows are closed. The irritation was characterized by mild pain and tearing in the eyes, with irritaton subsiding rapidly upon removal from exposure.

Other employees of the "Coating Prep." department, who had no direct exposure but must pass through the area, experienced eye irritation. These employees were the operators and assistant operators who's work station is in the air conditioned computer room and the slurry men who work in the back room. Irritation was reported to subside as soon as they entered the computer room or left the final mix area. Over an 8 month period, only two employees reported to the plant infirmary, one complaining of eye and skin irritation, the other had symptoms of gastritis.

A review of the "Coating Prep." department's raw materials list indicated the possible presence of three contaminants known to elicit the reported symptoms: formaldehyde, styrene and methylamine. Styrene could be present in the latex while formaldehyde and methylamine are reported by the manufacturer as decomposition products of Metasol D3TA. No odor of formaldehyde or styrene was detected by the NIOSH investigator.

Employee exposure levels to suspected concentrations of these three chemicals presented in Table 81, were evaluated by review of company data, OSHA survey data, and NIOSH environmental survey data.

Work practice observations and employee interviews indicated that the source of exposure was the sampling ports of each of the mix tanks. These sampling ports are normally kept closed during "cook", but are required to be open periodically (one to three times per hour) to collect QC samples. The length of time it took to collect these samples averaged 30 seconds. Employees indicated that symptoms were worse when these ports had been left oepn in the past.

OSHA sampling data indicated that there was no employee exposure to formaldehyde in the general work area where employees spent the majority of their time. However, all three data sources recorded levels of exposure at the sampling ports that were high enough to cause irritative symptoms in workers. NIOSH environmental sampling did not detect the presence of styrene or methylamine. The limit of detection for these chemicals was 0.01 mg per sample.

It was concluded during this investigation that the irritative symptoms are compatible with the known effects of formaldehyde exposure. It was recommended by NIOSH that a ventilation system designed to create a negative pressure inside the mix tanks would greatly reduce the possibility of formaldehyde escaping through the sampling ports, thus eliminating employee exposures to formaldehyde.

Table 81 SUMMARY OF ENVIRONMENTAL SAMPLING IN A COATING PREPARPATION DEPARTMENT

Formaldehyde - Criteria 1 ppm (30 Minutes) NIOSH

Location	Sample Time	Result
#1 Mix tank	200 min.	0.1 mg/m^3 (0.8 ppm)
#1 Mix tank	200 min.	0.5 mg/m^3 (.41 ppm)
#4 Mix tank	instantaneous	3 ppm
#5 Hot storage	instantaneous	ND*
#1 Mix tank	instantaneous	2 ppm
#5 Mix tank	instantaneous	2 ppm
#2 Mix tank	instantaneous	ND
#2 Hot storage	instantaneous	ND
Operators table	instantaneous	ND
#1 Mix tank	30 min.	0.51 mg/m^3 (0.42 ppm)
#5 Hot storage	30 min.	0.49 mg/m^3 (0.40 ppm)

Styrene - Criteria 100 ppm (8 hr. TWA)** OSHA/ACGIH

Location	Sample Time	Result
Final mix area	60 min.	ND
Final mix area	60 min.	ND

Methylamine - Criteria 20 ppm OSHA/ACGIH

Location	Sample Time	Result
#1 Mix tank	30 min.	ND
#5 Hot storage	30 min.	ND

*None Detected.
**Time Weighted Average

Chemical Vapor Exposure in a Kraft Paper Coating Operation

This investigation resulted from complaints of upper respiratory irritation and "hayfever like" reactions in workers exposed to vapors and mists generated when treating kraft paper with "Ferro-Pak W" or "Ferro-Pak MPI" coating liquids (81). Such coatings serve as corrosion inhibitors for wrapping material for metal parts.

The area of interest was the treating division of a large paper company when special coating materials are applied to kraft paper. Paper treatment oil, wax, Ferro-Pak W, MPI or B is scheduled according to customer demand. Ferro-Pak W is run only for one or two consecutive shifts, once or twice monthly. Ferro-Pak MPI is run for a similar period but only once every serveral months.

The plant operates two 8-hour shifts per day, five days per week and employs approximately 170 production personnel. Twenty nine people work in the treating division, as an evenly split work force to cover the two work shifts. Job classifications include Treaters and Treater Helpers, Boiler Tenders, Crate Makers and Carpenters, Sheeters, Cutters and Cutter Helpers, Wrappers, Trimmers, Rewinders and Floormen.

Boiler tenders, crate makers and carpenters work in the basement where the chemicals for the coating materials are mixed, lab tested and held at operating temperature (approximately 120°F) in vats. When needed, the coating material is pumped upstairs to the treating machine where it flows into the bottom of a holding tank which is about eight feet long, seven feet wide and three feet high. The surface of the liquid is kept approximately 6 to 8 inches above the bottom of the tank during the treating process. (Plant representatives stated that lines leading from the supply vats to the treating machine are steamed out after use of a particular treatment and that all treatments were "compatible" with no special drying time required for the paper.)

The kraft paper is unrolled and fed between rollers located above the holding tank, which transfer the treating liquid to the surface of the paper. The treated paper is collected on a metered take-up roll. Following the treating process, the paper roll is removed and run through several different machines to cut it to the sizes desired.

A large canopy exhaust hood is mounted over the treating machine. The open face of the hood is 8 feet wide, 11 feet long, and positioned 21 inches above the treating machine. The hood is also equippped with canvas side curtains to reduce cross drafts.

MPI coating mixture contains an inorganic oxidizing agent ($NaNO_2$), sodium benzoate, butyl benzoate, propylene glycol and poly-ethylene glycol, all of which may be mild primary irritants, and benzotriazole, which has caused some central nervous system depression with facid paralysis in animals (sensitization would appear unlikely). W coating mixture contains propylene glycol and polyethylene glycol, which may be mild irritants; in addition to caprylic acid, a relatively mild irritant with an unpleasant odor detectable at 0.008 ppm, and di-cyclohexylamine and morpholine, which are irritants to the skin, mucous membranes and respiratory tract and may cause sensitization. These substances may cause the body to release histamine and cause asthmatic attacks. Di-cyclohexylamine is an alkaline corrosive. Systemic effects from these two amines can include headache, nausea, faintness, and anxiety.

At the time of the initial walk through survey by the NIOSH physician, a simple oil coating was being run on the treating machine. The odor of the hot oil was detectable throughout the treating area but not into the adjacent laminating area. The NIOSH physician did not find this odor irritating, nor were the fumes in the basement irritating. At the time, the smoky haze from the vats in the basement was drifting into the area where the crater worked; the ventilation system did not appear to be drawing any of the mist up through the canopy hood. Smoke tube tests demonstrated that exhaust capture velocities were much too low to insure efficient operation and prevent dispersion of the mist into the work room air. After further inspection of the ventilation system, it was discovered that the exhaust fan blade had been removed for maintenance. A new blade was installed, but a subsequent check indicated that air flow exhaust volume was still not sufficient to capture all contaminated air.

Atmospheric vapor sampling conducted during the initial survey revealed no detectable levels had been collected on any of the 13 charcoal tubes analyzed for morpholine, di-cyclohexlamine and propylene glycol.

Table 82 summarizes the results of sampling and analyses for atmospheric concentrations of butyl benzoate. Highest levels measured where for those area samples taken near the side of the treating machine tank and in the mixing room. The highest personal exposure noted was 1.6 mg/m^3 butyl benzoate collected over a three hour sampling duration. This level equals approximately 0.22 ppm under normal atmospheric conditions (760 mm Hg and 25°C). Butyl benzoate was sampled as a tracer substance to obtain relative exposure data on total vapor concentraton. It was determined that vapors not detectable through atmospheric sampling may possibly exist at levels which could be objectionable or irritating for some exposed workers. However, the relative low levels of butyl benzoate detected, indicate that vapors of Ferro-Pak MPI released from the treating machine probably are not of sufficient concentration to present a toxic hazard.

Table 83 lists health problems considered to be work related by the workers. The non-directive question which was asked by both the industrial hygienist and by the doctor queried "Do you have any health problems at work or you feel might be related to your work?" The most salient complaints involved the smoke and bad odor ("W" in particular) and the irritation of the throat. Considering both spontaneous complaints and systematic questioning, 6 out of 29 workers had noted each of these complaints. There were two complaints of note. Two workers had a hay fever-like reaction to "MPI" in which their noses and sinuses became congested and in which they sometimes had difficulty breathing. One worker complained of wheezing when exposed to "W".

Table 82 ENVIRONMENTAL SAMPLING FOR BUTYL BENZOATE

Sample Type	Concentration (mg/m^3)	Location
Area	0.14	Work bench south of Tank
Area	6.06	Side of Tank
Area	0.64	25 ft. north of Tank
Personal	1.61	Treating Machine Operator
Personal	0.85	Treating Machine Helper
Personal	0.03	Scoring Operator
Personal	0.13	Carpenter
Personal	0.04	Cutter Helper
Personal	0.04	Sheeter
Personal	0.04	Chemical Mixer/Boiler Tender
Area	0.46	Work bench south of Tank
Area	9.37	Side of Tank
Area	0.55	25 ft. north of Tank
Personal	0.94	Treating Machine Operator
Personal	1.42	Treating Machine Helper
Personal	0.03	Scoring Operator
Personal	0.03	Cutter Helper
Personal	0.24	Sheeter
Personal	0.03	Chemical Mixer/Boiler Tender
Area	0.17	Basement-Mixer Room-Door Area
Personal	0.03	Cutter Helper
Personal	0.38	Treating Machine Operator
Personal	0.02	Boiler Tender/Crate Maker
Personal	0.66	Treating Machine Helper
Personal	0.03	Cutter Operator
Area	0.19	Work bench south of Tank
Area	0.63	Side of Tank
Area	0.42	25 ft. north of Tank

As a result of this investigation, NIOSH made the following recommendations:

- Ventilation should be improved, particularly exhaust ventilation from the treating machine and the ventilation in the basement. The overhead canopy exhaust hood over the treating machine is not an efficient design for ventilation of large cross sectional area.

- Although ventilation improvement will probably alleviate any problems for most of the workers, the two workers with hay fever-like reactions to MPI may have to use appropriate respirators during MPI runs or be assigned outside the area. Workers who desire to use respirators should be instructed in the proper techniques to insure a good face fit.

- Although the Ferro-Pak W was not found to affect the pulmonary functions of two workers tested, a third worker on the treatment machine was not evaluated. If he should have breathing problems felt to be due to Ferro-Pak W, it would be desirable to test him before and after a shift when the W is being run. In view of the lack of change in the other workers tested, this would appear to be an individual problem.

Table 83 ILLNESS THOUGHT TO BE WORK RELATED BY WORKERS, CURRENT AND PAST

Complaint	Number Giving Response on Non-Directed Questioning*	Additional Numbers Giving Response on Systematic Questioning**
None	14	2 less
Smoke or Bad Smell	4	2
Throat Irritation or Cough	4	2
Headache or Light Headedness	2	1
Hay Fever-like reaction to "MPI"	2	0
Wheezing with "W"	1	(Complaint made to Industrial Hygienist, never mentioned to Doctor
Shortness of Breath or Chest Discomfort	0	3
Skin Problems	0	1
Injury, Strains, etc.	5	2

*Twenty-nine workers done by Doctor and/or Industrial Hygienist
**Twenty of the twenty-nine workers done by Doctor.

Solvent Vapor and Dust Exposure in a Paper Coating (Flocking) Operation

In this investigation, NIOSH performed an environmental/medical study to determine the occupational hazard potential of airborne dust and Stoddard solvent in the flocking department of a greeting card manufacturer (82).

In this operation, flattened greeting cards are initially inserted beneath silk screens containing a preselected pattern mesh. An appropriate colored glue is squeezed through the silk screen onto the card, which is then dipped into the matching color flocking compound (dye rayon tow). The card is then vibrated on a beating bar to allow flock to adhere only to the glued areas. After being stacked verticaly in wooden shelves to dry overnight, the cards are folded and packed into boxes the following day. Persons flocking the cards are also responsible for the cleaning of the silk screens. The cleaning operation is conducted for approximately five minutes daily, and utilizes a mineral spirits solution.

The alleged hazard involved 6 persons employed in the flocking department with concern directed primarily to certain dermatitis and respiratory problems. One individual had developed a rather obvious wide spread thickening and mottling of the skin as well as wide flat warts; the dermatologist doubted any association with flocking. In addition to the above-described conditions, the employee also had a history of acrocyanosis and Raynaud's disease.

The second symptomatic worker interviewed had a history of brochitis and calcium on the lungs, which was claimed was not to be present prior to commencing employment at the plant. This employee's personal physician commented that pharyngitis, deep coughing and wheezing antedated employment and did not feel employment had changed the clincial picture. An examination at the plant revealed the employee to have a very mild erythema on the lateral portions of the neck in the flexure lines.

A third symptomatic worker gave a history of developing, from time to time, a slight rash in the antecubical fossae but had mainly been troubled with an aggravating throat condition. Complaints of a chronic sore throat and asthmatic bronchitis were also noted. An examination at the plant revealed the employee to have a very minimal erythematous patch in the nasal crease on either side of the nose. This employee's private physician felt that flocking particles would certainly tend to aggravated conditions such as a chronic nose or throat problems.

The last symptomatic worker interviewed revealed an itchy erythematous rash on the wrist since becoming an employee at the plant, and that a pre-existing sinus condition had been aggravated.

Two of the six workers had no complaints relating to dermatologic or upper respiratory conditions. Paper face masks were provided, althrough several of the symptomatic workers elected not to wear them because it made breathing more difficult. No complaints were received nor was evidence found to indicate that a narcosis problem existed among employees working with glues containing the Stoddard solvent.

A total of 22 air samples were collected during the NIOSH survey. Table 84 presents a summary of all environmental samples collected. During this sampling, the established standard for inert/nuisance dust (respirable fraction) of 5 mg/m^3 was exceeded in only one instance, while the established standard for solvent vapor was not exceeded.

From this investigation, NIOSH made the following recommendations:

- Improve dust collection to assist in eliminating mechanical skin irritation and upper respiratory tract conditions witnessed by persons employed in the flocking department.

Table 84 SUMMARY OF AVERAGE DUST/STODDARD SOLVENT CONCENTRATIONS

Inert/Nuisance Dust

	Number of Samples	Concentration (mg/m^3) Min.	Ave.	Max.	Applicable Standard (mg/m^3)
CENTRAL					
Total	2	0.5	0.8	1.1	15.0
PERSONAL					
Total	4	0.5	6.2	20.0	15.0
Respirable	4	-0-	0.4	0.6	5.0

Stoddard Solvent

	Number of Samples	Concentration (mg/m^3) Min.	Ave.	Max.	Applicable Standard (mg/m^3)
General Area	11	99	438	1,906	2,950

- Improvement of current housekeeping practices should be made. Dust on overhead ledges, floors, etc., can readily be dipersed to the in-plant atmosphere by traffic, vibration, and random air currents. Maintenance housekeeping should be mandatory, and employees should be informed of the need for those measures. Consideration should be given to increasing the frequency of the current practice of vacuuming floors 2-3 times each day.

- Discontinue the present practice of using compressed air to "blow" dust off employees' uniforms. Dust concentrations are increased considerably by this practice.

- The "screening" out of future potential employees with preexisting chronic sinus and throat illness is recommended.

- Wearing of long sleeve uniforms in the flocking areas is recommended to prevent deposition of airborne flock in elbow creases. In addition, a clean, change of uniform should be provided daily.
- Encourage the use of paper face masks by all persons in the flocking area, including management, upon entering the area.

- Insure that filters on current A/C systems are adequately maintained.

Dust, Smoke and Solvent Vapor Exposure at a Newsprint Finisher

During this investigation NIOSH evaluated employee exposures to air contaminants in the letter press room of a large printing company, where workers were experiencing dizziness, headache, burning eyes, and allergic disorders (83).

At the printing company, magazines are printed on rotary and multicolor printing presses. Newsprint and a variety of higher quality papers are utilized. Printing inks are composed of hydrocarbon vehicle with both organic and inorganic pigments. Kerosine and Ottoson No. 9 solvent are used to clean press rollers, ink wells, etc. Trichloroethylene is used to soften the glue used in splicing paper.

Employees are exposed to paper dust during the "blow-down" of presses. Paper dust generated by paper cutting (slitter knives) and by page folding in the printing operation accumulates on press machinery. Periodically (approximately once per week for rotary presses and once per month for multicolor presses) air hoses are used to dislodge dust accumulations. Blow-down is started at the upper level of a press and proceeds to ground level. Dust which eventually settles to the floor is swept up and discarded. This procedure requires approximately 20 to 30 minutes to complete. The employees (usually two) handling the air hoses wear gauze-type respirators during this operation.

Employees are exposed to varying concentrations of "press oven smoke" throughout the letterpress room. The printing presses utilize oven dryers to evaporate excess ink vehicle or solent from printed paper prior to folding. The hydrocarbon ink vehicle driven off by the drying ovens is present in oven effluents in the form of vapor or smoke. Ovens are hooded and exhausted to the outdoors. However, incomplete enclosure, leaks in enclosures, and recirculation of exhausted contaminated air results in variable concentrations of press oven smoke within the letterpress room work areas. In general, smoke concentratins are highest above presses in the vicinity of ceiling structural members.

Press rollers, ink wells, etc. are cleaned using kerosine and Ottoson No. 9 solvent. These solvents are used by hand application and are also applied to the "web" (paper) in small quantities which is then cycled through the press. Employees are primarily exposed to these solvents via direct skin contact.

As new rolls of paper are fed into a press, a 1 or 2 second spray of trichloroethylene is applied to the glue coated starter of the new roll. The trichloroethylene softens the glue so that a strong paper splice is achieved. One employee working on each press utilizing this splice procedure is exposed to a transient odor of trichloroethylene for less than 1 minute every 35 minutes throughout the workshift.

The potential acute and chronic health effects of exposure to "press oven smoke" were of primary interest to the medical evaluation. Review of the information collected by nondirected interviewing of 24 employees by the

NIOSH industrial hygienist suggested that press oven smoke was adversely affecting letter press room employees. The major complaints reported were headaches and burning eyes, particularly when the oven smoke was heavy. About one third of the workers reported some shortness of breath, but it did not seem out of line for the ages and smoking habits of the men. The major physical findings were reddening of the conjunctiva or throat which was found in 25% of the men examined. These findings related more to smoking habits than to any history of symptoms said to be due to the oven smoke. The solvents did cause some of the expected symptomatology (skin irritation and one case of reported intoxication) when not handled properly. Paper dust aggravated pre-existing allergic respiratory problems in two men and was a nuisance to other workers.

Employee exposures to trichloroethylene associated with the splicing of paper were evaluated by observing duration and frequency and exposure, and the quantity of trichloroethylene used. In the judgement of the investigators, trichloroethylene vapors encountered in the paper splicing operation did not constitute a hazard to employee health.

Employee exposures to paper dust in the "blowing down" of presses were evaluated by observing work practices, exposure duration, and by measurement of breathing zone concentrations of airborne paper dust. No significant amount of lead was found in the paper dust collected in air samples. Although the magnitude of employee exposure to air borne paper dust can be significant, in judgment of the investigators, the short duration and infrequent nature of exposures reduced the significance of this potential health hazard to that of an occupational nuisance or mild irritant to persons with allergic respiratory disorders.

Employees exposures to "press oven smoke" were evaluated by identifying major smoke constituents and by intervewing and examining a sample of employees exposed to the smoke. Employees were found to experience mild irritative symptoms from exposure to "press oven smoke" which, in the judgment of the investigators, may have been attributed to low concentrations of aldehydes found in the smoke.

In the interest of reducing subsequent employee exposures, the following recommendations were made:

- Local exhaust ventilation could be installed at press slitter knives (the major sources of paper dust generation) to significantly reduce accumulations of dust by capturing dust as it is generated.

- During "blow-down," air hoses should be used only to dislodge dust from press surfaces. Before proceeding to the next lower catwalk level, the majority of settled dust on catwalks should be swept or shovelled into refuse containers rather than blown successively from each catwalk and finally to ground level. This modification in procedure should significantly reduce exposure and also reduce transfer of dust to adjacent presses.

- Employee exposures to press oven smoke, especially episodic elevated exposures during adverse atmospheric conditions, could be significantly reduced by overhauling the plant's ventilation system. Negative pressure should be corrected by supplying additional makeup air. Ventilation structures should be repaired to seal leaks; cleaned to reduce air flow resistance and fire hazard; and modified to eliminate back flow and recirculation of contaminated air.

- Solvent use should be reviewed, particularly its use in confined spaces, since one employee gave a history compatible with toxic exposure to solvent fumes while cleaning the press ovens.

Exposure to Nuisance and Starch Dust at a Corrugated Paper Finisher

At the request of the employer, an HHE was conducted to determine the extent of worker exposure to dusts during various operations in the manufacture of corrugated shipping containers (25). Several employees working in this operation complained of nasal and eye irritation and headaches.

The company at which this investigation was performed is a manufacturer of corrugated shipping containers of all types. At the site, a corrugation machine is used to combine heavy sheets of paper to corrugated pieces of container material. These pieces are cut to size and hand stacked at the "cut off" end of the machine. Approximately 6 men handle this operation during a shift. Dust is generated at the "cut off" end where twin blades slice pieces of the material to size. Two flexible hoses are provided for local exhaust ventilation, but some dust is still generated.

The containers which are ready for final processing are sent to the printing machine where they are stamped for identification and trimmed. Generally, one person feeds the machine while three of four people stack and count the sheets of material as they roll off of the "die cutter". Dust is generated from the cutting operation as the pieces of material are sent through the printing machine. Local exhaust is provided for dust collection.

One scrapping operation was observed during the NIOSH visit, where local exhaust ventilation systems were used to collect scrap pieces of material. In this procedure, scrap pieces are pulled into a cyclone on the roof which contains a chute. The chute feeds a baling machine which compresses the scrap into bales. One worker is used to hand feed scrap into the baler.

The mixing of starch is an isolated operation which is performed by one operator, once a day for a period of two hours. The operator opens 50 pound bags of starch by cutting the bag with a knife and dumping the contents into two large vats partially filled with water. During the dumping operation the employee is exposed to airborne particulate. During the NIOSH visit, the mixing operator was not observed wearing a respirator during this operation.

Fifteen confidential employee medical interviews were conducted in an attempt to detect any adverse health effects attributed to the work environment. Three of the 15 employees had complaints. The responses indicated that dust was acting as an irritant to the nasal passages and eyes and was not producing any symptoms to the lower respiratory tract. The predominant symptoms of exposure to the dust were sneezing, dry or plugged noses and headaches.

Table 85 presents the results of 24 environmental samples taken at various working locations. Two of the 24 samples analyzed exceeded the "nuisance dust" criteria used in this evaluation. One personal breathing zone sample (for total dust) taken during the baling operation was 12.7 mg/m^3 which is in excess of the ACGIH TLV. This level can be attributed to the following: 1) lack of ventilation at the baler, 2) sloppy operation, 3) the use of an air hose to clean the baler area. The baler operator does not wear a respirator during the baling operation.

One personal breathing zone sample (for total dust) taken during the starch mixing operation was 15.1 mg/m^3, a level which is in excess of the ACGIH TLV and OSHA standard for an 8-hour time weighted average exposure. However, this sample was for a 3-hour period. As stated above, the mixing operator was not observed wearing a respirator during this operation.

All other dust samples collected for respirable and total (nuisance) dust were at concentrations below the ACGIH TLV and the OSHA standard.

The carbon monoxide readings that were taken during these operations showed an average level of 5 ppm. This is below the existing standard of 50 ppm and the NIOSH recommended criteria of 35 ppm for an 8-hour time weighted average.

Based on the environmental sampling results and the confidential medical review, the following recommendations were made by NIOSH:

- Local exhaust ventilation should be designed for the baler and mixing tanks and installed as soon as possible to lower the dust levels in the area.

- Until engineering controls are installed at the baler and mixing tanks, a dust respirator should be worn. Respirators used should be those certified under the NIOSH Respirator Standard, 30 CFR, Part II.

- The present procedure of using air hoses to clean the baling area should be discontinued and replaced with vacuum cleaning methods. Air hoses for cleaning should not be used in any areas.

Asbestos Dust Exposure During Corrugated Paper Finishing

The HHE was conducted to determine health hazards related to exposure to asbestos dust in the baling, corrugation and printing section of a manufacturer of corrugated shipping containers (84).

Table 85 PAPER AND STARCH DUST SAMPLES TAKEN DURING CORRUGATED CONTAINER PROCESSING

Job and/or Location	Paper Dust mg/m^3 (Nuisance Dust) Total Dust	Paper Dust mg/m^3 (Nuisance Dust) Respirable	Starch Dust mg/m^3 (Nuisance Dust) Total	Starch mg/m^3 (Nuisance Dust) Respirable
Corrugator	0.4	---	---	---
Corrugator	---	0.1	---	---
Shafter	1.0	---	---	---
Shafter	---	0.3	---	---
Off Bearer	2.1	---	---	---
Off Bearer	---	0.2	---	---
Slotter	2.7	---	---	---
Slotter	---	0.2	---	---
Stacker	0.7	---	---	---
Baler	12.7	---	---	---
Baler	---	0.3	---	---
Bundler	1.1	---	---	---
Saw Area	0.4	---	---	---
Slitter	0.5	---	---	---
Slitter	---	0.3	---	---
Utility	0.8	---	---	---
Utility	---	0.2	---	---
Chopper	0.5	---	---	---
Baler	5.1	---	---	---
Baler	---	0.5	---	---
Stacker	3.4	---	---	---
Stacker	---	0.9	---	---
Mixer	---	---	15.1	---
Mixer	---	---	---	0.5

The 1976 ACGIH TLV for total nuisance dust is 10 mg/m^3
The current OSHA standard for total nuisance dust is 15 mg/m^3
The 1976 ACGIH TLV and current OSHA standard for respirable fraction is 5 mg/m^3

The plant in which this investigation took place, manufactures various shipping containers laminated with asbestos. One of the initial steps in special asbestos orders is completed at the corrugation machine where asbestos sheets are combined and laminated to corrugated pieces of container material. These pieces are cut to size and hand stacked at the "cut off" end of the machine. Approximately 6 men handle this operation during a shift. The dust is generated at the "cut off" end where twin blades slice pieces of the laminated material to size. Two flexible hoses are provided for local exhaust ventilation, but some dust is still generated. The set-up is the same for regular and asbestos products. During these operations, respirators are not worn by workers.

The containers which are ready for final processing are sent to the printing machine where they are stamped for identification and trimmed. Generally, one person feeds the machine while 3 of 4 people stack and count the sheets of material as they roll off the "die cutter." Dust is generated from the cutting operation as the pieces of material are sent through the printing machine. The worker feeding the machine is the only one wearing a respirator. Local exhaust for dust is not provided.

One small scrapping operation was observed during the NIOSH visit. The local exhaust ventilation systems were used to collect scrap pieces of material. The scrap pieces of asbestos were pulled into a small room which contains a chute. The chute feeds a bailing machine which compresses the scrap into bales. One worker stood at the edge of the room to shove the scrap into the chute with a rake. This operation took about one hour to complete each time an asbestos order was run. This worker wore a respirator during the baling operation.

The occupational health hazards for all of these operations were judged to be potential exposure to asbestos dust.

During a medical review, several employees were questioned concerning their experiences with asbestos material. This questioning concentrated on outward signs and symptoms associated with lung ailments. None of the workers claimed that they were suffering any adverse effects from working with asbestos. One employee did express that he suffered from some shortness of breath, but he was also a heavy smoker. Further inquiries revealed that no routine medical examination program was provided by the company to employees working with asbestos.

Environmental sampling of the baling, printing, and corrugation processes were conducted for airborne concentrations of asbestos fibers. The results of this sampling are presented in Table 86. According to these data, fiber counts for the baling area, as well as for the baling operator, did not exceed the present standard of 5.0 fibers per cc (8-hour time weighted average) or 10.0 fibers per cc (ceiling concentration) promulgated by the U.S. Department of Labor. However, fiber counts were high in the "tail off" section of the printing machine operation where the "stackers" and "counters" work. The feed side of the printing machine was less dusty. As were the breathing zones of the workers attending the corrugation machine.

Based on this investigation, NIOSH made the following recommendations:

- Local exhaust ventilation should be designed for the printing machine and installed as soon as possible to lower the dust levels in that area.
- Until engineering controls are installed at the printing machine, all workers must wear approved dust respirators for asbestos in the area.
- The worker attending the baling machine should wear an approved respirator whenever scrap asbestos is being baled.
- The present procedure of using air hoses to clean the printing machine should be discontinued and replaced with vacuum cleaning methods. Air hoses for cleaning should not be used in any area where asbestos is being processed.
- The rules and regulations governing the use and control of asbestos in industry are contained in the Federal Register (Volume 27,

Section 1910.93a). A copy of this document should be obtained by management. The requirements for environmental and medical monitoring of workers using asbestos should be followed. Housekeeping requirements are detailed in this document. These provisions should be followed carefully by management.

Table 86 ASBESTOS COUNTS IN FIBERS/CC

Area/Occupation	Asbestos Count*
Baling - Operator	2.1
Baling - Central Area	0.3
Printer - Feeder Operator	2.5
Printer - Stacker (tail off)	5.6
Printer - General Area (control panel)	6.6
Corrugator - Knifeman	0.4
Corrugator - Knifeman	0.6
Corrugator - Assistant Operator	0.2
Corrugator - Assistant Operator	0.3
Corrugator - Stacker (tail off)	0.7
Corrugator - Stacker (tail off)	1.0
Corrugator - Stacker (tail off)	0.3
Corrugator - Stacker (tail off)	0.7
Corrugator - Stacker (tail off)	0.4
Corrugator - Stacker (tail off)	1.0

*Units of measurement - fibers/cc - the number of fibers longer than five micrometers in length per cubic centi- meter (cc) of air.

Paper Dust Exposure at a Corrugated Paper Cutter

This survey was made to determine the health hazard related to exposures to paper dust at a producer of corrugated paper containers (85).

Among the various operations at this plant, the one which was investigated involves the cutting and trimming of corrugated "posts" and "dividers". The posts are cut to size on an automatic two-blade trimsaw. Approximately 4 or 5 workers are in attendance at this operation during a shift. Dividers are cut to size by workers operating bandsaws. One bandsaw is attached to a shaking device where two helpers are required while the other bandsaw operator needs only one helper. Respirators and ear protection are not worn by employees in this area of the plant.

During the NIOSH visit, high volume air samples were taken in the breathing zone areas near the trimsaw and bandsaw operations. The results of these samples are presented in Table 87. These samples, which ranged between

22.8 and 89.2 mg/m^3, were well above the U.S. Department of Labor Standard of 15 mg/m^3 of total dust. It was determined by NIOSH that these levels were too high to provide a comfortable and healthful work environment and that steps should be taken to lower the dust levels. In that regard, the following recommendations were made by NIOSH:

- Local exhaust ventilation with a dust collecting system should be installed on the trimsaw and both bandsaws.
- Workers should wear approved dust respirators in the trimsaw and bandsaw areas until engineering controls can be installed.

Table 87 TOTAL DUST CONCENTRATIONS IN BREATHING ZONE AREA SAMPLES COLLECTED NEAR THE TRIMSAW AND BANDSAW OPERATIONS

Sample No.	Area/Occupation	Total Dust/Concentration (mg/m^3)
1	Trimsaw Packing	22.8
5	Trimsaw Packing	23.1
2	Trimsaw Loading	89.2
3	Trimsaw Loading	78.8
4	Trimsaw Loading	54.8
6	Bandsaw with Shaker	52.9

Silica, Asbestos, Formaldehyde and Asphalt Exposure at a Building Paper Plant

This investigation was performed to determine whether fibrous glass in crystalline silica used in the production of asphalt shingles are toxic in the concentrations used (18). Although the request only cited these substances, an attempt was made, for the purposes of completeness, to evaluate worker exposure to some of the other materials used in the work place such as asbestos, formaldehyde and asphalt (petroleum).

The plant at which this investigation was performed produces asphalt shingles with cores made of either paper felt or fibrous glass. The core is usually referred to as the "matte". Some of the paper matte contains a small percentage of asbestos. When the matte is paper, it is fed from large rolls through a series of accumulation loops before entering the asphalt "saturator". The large rolls are continuous since they are attached together via a splicing operation. In the saturator, hot petroleum liquid asphalt which has been heated to approximately 400°F, is applied to the matte as it passes through another series of loops. When it leaves the saturator, the matte has been completely saturated with asphalt. The saturated matte then passes through a baffle system of liquid asphalt which has been thickened. This bath and baffle system is known as the "coater". When fibrous glass matte is run on the production line, the saturator is not used, and the matte goes directly through the coater. As either type of matte leaves the coater, granules of the desired color are dropped on the top side of the matte and pressed into the still hot asphalt with a roller ("pressroll area").

Additionally, a mixture of sand and talc is placed on the backside of the matte to prevent sticking where three thin strips of polyester film are applied. The material then passes through a water spray and another series of cooling and accumulation loops ("cooling section"). An intermittent strip of liquid asphalt is applied to the shingle at the "sealamatic resin strips applicator" as it leaves the cooling loops and proceeds to the final steps (cutting, stacking, wrapping, and storage).

Two shifts were in operation during NIOSH's two visits to the plant. Approximately 12 employees can handle the entire main shingle line. A "splicer" and "splicer helper" are responsible for feeding and splicing the rolls of paper or fibrous glass matte. One worker ("coaterman") handles the coater and one employee tends the pressroll and cooling section areas of the shingle line. This "slateman" is responsible for monitoring the flow of granules and/or loading the minerals into ventilated hoppers in the slateroom which is located above the coater.

Rolled roofing products are processed on a smaller line ("rolled line") which is parallel to the main shingle line. A "backtender" feeds the matte which passes through a saturator, continues through a series of cooling loops, and is rolled and cut into the final product. One worker ("machine tender") watches the entire line, and two employees handle the rolling, cutting, and stacking of the final product.

During the NIOSH visit, fibrous glass matte was being processed and samples for fibrous glass and crystalline silica were taken. Additionally, since workers were being exposed to essentially the same air contaminants as those employees in other asphalt shingle manufacturing plants, spot sampling for asphalt fumes, volatile hydrocarbons, polynuclear aromatics (especially benz(a)pyrene), formaldehyde, and asbestos was conducted.

Exposure to fibrous glass fibers is greatest among employees working near the uncoated matte and diminishes as the material reaches the end of the process. Any exposure to asbestos will follow the same pattern as for fibrous glass.

The saturators and the coater, which have mechanical ventilation systems known as High Efficiency Air Filters (HEAF). The saturators are enclosed and under negative pressure. Employees only enter the saturator during breakdowns and spot checks and the greatest exposures to asphalt fumes plus any substances contained in the fumes occur at this time. No respiratory protection is used when employees enter the saturators. The coater has partial enclosure and, although this unit captured most of the fumes and smoke, some of the contaminants were escaping into the general work area during the NIOSH visits. Thus, the potential for the greatest asphalt fume exposure is at the coater and in the saturators, but it seems that low-level exposures can occur throughout the shingle manufacturing line.

Exposures to workers from crystalline silica can occur in the slateroom and near the cooling section and coater. The sources of silica are colored granules and sand which are applied to the asphalt shingles. The potential for a health hazard from silica is generally confined to these areas of the shingle manufacturing line.

During the NIOSH visit, fibrous glass samples were taken in the breathing zones of the splicer, splicer helper and coaterman and in the general area of the coater. Three samples in each location were taken, the results of which indicated that the lower limit of detection (0.01 fibers/cc) was not reached. Additionally, so few fibers were found that representative sizing of fibers could not be done.

Gravimetric dust sample results for the splicer, splicer-helper and in the general area of the coater indicated that the NIOSH recommended time weighted average (TWA) of 5.0 mg/m^3 was not exceeded. The TWA levels measured at these locations were 0.46, 0.33 and 2.87 mg/m^3 respectively, and most of the dust was evidently not fibrous glass.

Three asbestos samples covering over seven hours of a work shift were taken in the breathing zone of the back tender of the rolled line. The rolled line uses a paper matte which contains a small amount of asbestos. The asbestos counts were 0.25, 0.18 and 0.13 fibers/cc. Based on these three samples, the TWA was 0.19 fibers/cc. This level of asbestos was well below the current enforceable standard of 2.0 fibers/cc but was in excess of the NIOSH recommended limit of 0.1 fibers/cc.

Table 88 contains the results of samples taken for crystalline silica. According to the calculated limits based on the percent of SiO_2 in the samples, the slate man was exposed to potentially toxic levels of crystalline silica. Dust respirators were mandatory in most areas where the slateman worked, but this policy was not enforced adequately. In the sample collected in the breathing zone of the cooling section operator, exposure was well below the calculated limit. Two general area samples (respirable and total dust) were taken in the press roll area over a work shift, where the respirable dust level was found to be below the calculated limit; the total dust level, however, was slightly high. (Although no one works in the press roll area, the cooling section operator will occasionally rotate through there.)

Asphalt fume sample results are presented in Table 89. According to this data, the cyclohexane soluble fraction (which is assumed to be the asphalt fume portion) for the coaterman was below the current NIOSH and ACGIH criteria for asphalt fume of 5.0 mg/m^3. The two cyclohexane soluble fraction results found in the saturator would indicate that the asphalt fume concentration exceeded the criteria standard. However, workers enter the saturator only occasionally. Regarding the aromatic hydrocarbons, only a trace of toluene was found in the samples taken on the coaterman, cooling section operator and machine tender and these levels were well below the current CAL/OSHA standard of 375 mg/m^3 (TWA) for toluene. In the same samples, total aliphatic hydrocarbon levels were found to be respectively 8.1, 6.0 and 17.5 mg/m^3. The results represented mixtures of long-chain hydrocarbons (C-7 to C-12). No criteria exist for long-chain hydrocarbons C-10 and above. The TLV's for C-7, C-8 and C-9 are respectively 1600, 1450 and 1050 mg/m^3. NIOSH recommends a limit for the alkanes (C-5 to C-8) of 350 mg/m^3. In any case, the levels found in these samples were extremely low.

Table 88 CRYSTALLINE SILICA SAMPLES BY AREA OR OPERATION COLLECTED IN BREATHING ZONE AND GENERAL AREA SAMPLES

Area or Operation	Type*	% SiO_2	Dust Conc.	Calculated Limit**
Slateman	R	9.6	1.25 mg/m^3	0.86 mg/m^3
Slateman	T	28.7	6.11 mg/m^3	0.95 mg/m^3
Cooling Sect. Op.	R	0.0	0.38 mg/m^3	5.00 mg/m^3
Pressroll General Area	R	0.0	0.67 mg/m^3	5.00 mg/m^3
Pressroll General Area	T	25.0	1.95 mg/m^3	1.07 mg/m^3

*Samples were both respirable (R) and total dust (T) samples.

**Limits for dust exposures were calculated using the following formulas:

$$\text{Respirable samples in mg/m}^3 = \frac{10\ \text{mg/m}^3}{\%\ \text{SiO} + 2}$$

$$\text{Total dust samples in mg/m}^3 = \frac{30\ \text{mg/m}^3}{\%\ \text{SiO}_2 + 3}$$

Table 89 ANALYSES FOR TOTAL WEIGHT, CYCLOHEXANE SOLUBLE FRACTION, AND VOLATILE HYDROCARBONS IN ASPHALT FUME SAMPLES

Area or Operation	Tot. Wt.[1] mg/m^3	Cyclo. Sol.[2] mg/m^3	Tol.[3] mg/m^3	TAHC[4] mg/m^3
Coaterman	4.2	3.3	0.6	8.1
Coaterman	5.1	3.9	*	*
Cooling Sect. Op.	0.3	0.7	0.4	6.0
Cooling Sect. Op.	1.0	1.6	*	*
Machine Tender	0.4	1.8	0.4	17.5
Machine Tender	2.8	0.6	*	*
Bulk in Saturator	7.6	8.6	*	*
Bulk in Saturator	7.7	9.9	*	*

[1] Total weight concentration.
[2] Cyclohexane soluble fraction.
[3] Toluene concentration.
[4] Total aliphatic hydrocarbons.
*Analysis not reported.

Table 99 contains results for polynuclear aromatic hydrocarbons (PNA's). Levels of PNA's in petroleum asphalt the are highly variable and are usually found only in trace amounts. All the PNA's analyzed for in these samples were selected because of some evidence of carcinogenicity. However, no standards or recommended criteria exist for these compounds. Of primary interest is benz(a)pyrene (BAP) whose carcinogenic activity is the most documented. The U.S. Department of Labor, in its Report of the Standards Advisory Committee on Coke Oven Emissions (May 24, 1975), recommended that a maximum exposure to BAP be set at 0.2 g/m^3 (TWA). In each sample taken inside the saturator, BAP was present and the levels were 1.6 and 2.4 g/m^3. Regarding the personal samples, the coaterman, cooling section operator, and machine tender were exposed to BAP levels of roughly 0.2 g/m^3 on some occasions. It was therefore apparent that low levels of BAP can be measured on occasion in the work atmosphere and levels of some concern may be found in the saturator.

Table 90 ANALYSES FOR POLYNUCLEAR AROMATIC HYDROCARBONS (PNAs) INCLUDING BENZ(a)PYRENE (BAP) IN ASPHALT FUME SAMPLES (g/m^3)

Area or Operation	BAP[1]	BAA[2]	F[3]	P[4]	C[5]
Coaterman	0.22	ND*	ND	ND	ND
Coaterman	ND	0.20	ND	ND	0.50
Cooling Sect. Op.	0.23	ND	ND	ND	ND
Cooling Sect. Op.	ND	ND	ND	ND	ND
Machine Tender	0.25	ND	ND	ND	ND
Machine Tender	0.03	ND	ND	ND	ND
Bulk in Saturator	1.60	ND	ND	ND	ND
Bulk in Saturator	2.40	6.3	ND	ND	ND

*Not detected (below limits of detection of the analytical method)

[1] Benz(a)pyrene

[2] Benz(a) anthracene

[3] Fluoranthene

[4] Pyrene

[5] Chrysene

No problems were expressed by employees concerning irritation due to formaldehyde, but two samples were taken as confirmation of formaldehyde levels. One sample was taken near the splicer, where the formaldehyde concentration was 0.03 parts per million over a work shift. One sample at the coater showed a level of 0.07 ppm. In terms of the CAL/OSHA standard of a peak concentration of 2.0 ppm, these levels seemed extremely low.

On the basis of this NIOSH investigation, the following recommendations were made:

- The slate transfer system should be looked at and any leaks should be repaired. The feasibility of adding local exhaust ventilation at the slate transfer points should also be studied.

- The slateman should wear a NIOSH-certified respirator whenever he works in the slate area.

- Wearing of NIOSH-certified respirators in mandatory respirator areas of the shingle line should be strictly enforced.

- Whenever any worker enters a saturator, a NIOSH-certified respirator efficient against polynuclear aromatic hydrocarbons and asphalt fumes should be worn.

- The HEAF units should be serviced since asphalt fumes and smoke were escaping from around the units over the coater and were entering the general work atmosphere.

- The possibility of using some type of engineering controls at the feed ends of the shingle and rolled lines should be studied since asbestos fibers were still present in the work atmosphere in excess of NIOSH's recommended limit.

- Periodic environmental monitoring for crystalline silica, asbestos, and polynuclear aromatic hydrocarbons, where applicable, is recommended.

- NIOSH Criteria Documents have been published for Fibrous Glass, Crystalline Silica, Asbestos, and Asphalt Fumes. Workers who are exposed to any of these substances as defined in the documents should have medical surveillance as outlined in the documents.

Asphalt (Hydrocarbon) and Dust (Silica) Exposure at a Roofing Felt Plant

This HHE was performed to determined whether materials present in the production of asphalt shingles and rolled roofing materials are toxic to production workers (86). The materials involved were felt, asphalt (petroleum), colored granules, limestone, talc and mica.

The company at which this investigation took place produces asphalt shingles and rolled roofing products. This plant also produces their own rolled felt and rolled fibrous glass. The rolled felt is fed in a continous ribbon through accumulation loops into the saturator. In the saturator, hot asphalt (petroleum) at approximately 400 degrees Fahrenheit is sprayed and flowed onto the felt. As the felt exits the saturator, it is completely saturated with asphalt. The saturating process is enclosed in a cinder block enclosure that has local exhaust ventilation; the entire enslosure is kept under negative pressure. The saturated felt then enters an enclosure where the material is passed over a series of loops for cooling purposes. This enclosure utilizes local exhaust ventilation with the exhaust air being used as make-up air for the saturator. When the doors to this cooling chamber are left open, fumes escape into the general atmosphere. After the saturated felt leaves the cooling loops it passes to the coater. At this point, hot asphalt that has been thickened with limestone is flowed onto the top side of the felt. It is spread with rollers and passes on to the press area where the colored granules are dropped onto the surface and pressed into the asphalt. There is no local exhaust ventilation over the coater or press area; fumes and dust can be seen in this area. After the granules have been pressed into the asphalt, a mixture of talc and mica (sand has since been used in place of the mica) is applied to the back side of the material to prevent sticking. There are no controls on this process to keep the dust from entering the general atmosphere. This material is then passed through a water spray and another series of accumulation loops for cooling. From there, it passes to the cutter where the individual shingles are cut from the continuous ribbon. The shingles are automatically stacked, wrapped and put into storage.

There are 13 to 15 employees working in this area per shift for the first and second shifts. The third shift has a reduced crew for the running of rolled roofing products. The exposure that these men have to the various chemicals is variable. Each operation has a worker assigned to it; exposure is mainly to the materials that are added at that point. In addition, the felt ribbon may sustain a break which requires rethreading of the felt through the saturator and removal of the broken felt. In order to accomplish this, the doors of the saturator are opened with one or more employees entering the saturator to do the rethreading. This results in an exposure to concentrated asphalt fumes inside the saturator.

During a medical review, it was found that many of these workers experienced eye, nose and throat irritation that could have been caused by excessive dust levels and asphalt fumes. Skin irritation was noted on days when fibrous glass and felt impregnated with fiber glass was run. More serious symptoms were not apparent to the investigators and the study did not include further medical followup.

Tables 91 through 97 present the results of environmental test samples that were performed for airborne particulate, benzo(a) pyrene, asphalt fumes, aliphitac hydrocarbons, free silica, and specific polynuclear aromatic hydrocarbon air concentrations. On the basis of these tests, it was concluded that the slateman, pressman, granuleman and coaterman were exposed to excessive concentrations of total dust. The granule man was also exposed to excessive concentrations of free silica. These determinations were based on breathing zone concentrations that were in excess of the evaluation criteria used for this study. In addition, dryness of the nose and throat was experienced by these workers.

The saturator man's exposure to asphalt fumes was not considered to be toxic based on the eight-hour 5 mg/m^3 time weighted average criterion in existence at the time the environmental sampling was conducted. The NIOSH criterion of 5 mg/m^3 for any 15 minute period could be exceeded, however, when this worker has to spend at least 15 minutes inside the saturator during times of rethreading or other maintenance work, based on a measured concentration of 53 mg/m^3 of asphalt fumes measured in the saturator.

Table 91 TOTAL AND RESPIRABLE PARTICULATE AIR CONCENTRATIONS

Type of Sample	Job or Location	mg/m^3
Total Particulate	Dry Felt Man	3.65
Total Particulate	Dry Felt Man	2.78
Total Particulate	Saturator Man	2.39
Total Particulate	Coater Man	11.86
Total Particulate	Coater Man	15.61
Respirable Particulate	Coater Man	0.46
Total Particulate	Press Man	21.97
Total Particulate	Press Man	8.27
Respirable Particulate	Press Man	0.49
Total Particulate	Granule Man	28.82
Total Particulate	Granule Man	2.30
Respirable Particulate	Slate Man	1.16
Total Particulate	By Slate Bins	0.47
Total Particulate	Lead Man	5.29
Total Particulate	Cutter Man	0.94
Total Particulate	Conveyor Man	2.07
Total Particulate	Conveyor Man	0.58
Total Particulate	Wrapping Machine Operator	1.40
Total Particulate	Wrapping Machine Operator	0.59
Total Particulate	On 3rd Deck by Door to Slate Bin Above Coater	112.27
Total Particulate	On 1st Deck Above Coater	54.68

Excessive concentrations of dust and asphalt fumes were also measured in the area on the decks above the coater, wherein samples indicated that total dust and asphalt fume concentrations were 5 to 11 times the evaluation criteria. This area is not a normal work station; however, anyone working in this area to perform maintenance or other types of work would be subjected to excessive concentrations of total dust and asphalt fumes.

Employees' exposures to benzo(a)pyrene, other polynuclear aromatics (PNA's), alpha and beta naphthylamines, aliphatic hydrocarbons and aromatic hydrocarbons were not toxic at the concentrations found. This determination was based on the low levels measured and the absence of the compounds in the breathing zone samples taken for this study.

Fibrous glass and formaldehyde exposures were not measured since they were not processed during this study.

Table 92 BENZO(A)PYRENE (BAP) AIR CONCENTRATIONS

Job or Location	BAP mg/m^3
Saturator Man	0.12
Saturator Man	0.12
Coater Man	0.12
Coater Man	0.14
Press Man	0.13
Press Man	0.13
Relief Man	0.11
Relief Man	0.13
Lead Man	0.095
Lead Man	0.14
Foreman	0.10
Foreman	0.14
Cutter Man	0.095
Fork Lift Driver	0.11
Wrapping Machine Operator	0.17
Wrapping Machine Operator	0.13
On 3rd Deck by Door to Slate Bins Above Coater	0.20

Table 93 ASPHALT FUME, CYCLOHEXANE SOLUBLE AIR CONCENTRATIONS

Job or Location	Total Particulates (Includes Asphalt Fume) mg/m^3	Cyclohexane Solubles mg/m^3	Asphalt Fume (Calculated) mg/m^3
Saturator Man	2.39	0.76	2.3
Coater Man	11.86	0.21	0.6
Coater Man	15.61	1.06	3.2
Press Man	21.97	0.54	1.6
Press Man	8.27	0.30	0.9
Wrapping Machine Operator	1.40	0.77	2.3
Lead Man	5.29	0.76	2.3
Foreman	--	0.96	2.9
1st Deck Above Coater	112.0	6.51	19.5
3rd Deck Above Coater	54.6	4.45	13.4
Bulk Air Sample Collected in Saturator	53.3	16.7	53.3

Table 94 ALIPHATIC HYDROCARBON AIR CONCENTRATIONS

Job or Location	Total Identified Aliphatics mg/m^3	Unidentified Aliphatics mg/m^3	Total Aliphatics mg/m^3
Saturator Man	2.96	3.65	6.62
Saturator Man	6.97	8.99	15.96
Coater Man	0.27	0.24	0.51
Coater Man	0.20	0.28	0.48
Press Man	0.37	0.25	0.67
Press Man	0.67	0.51	1.18
Wrapping Machine Op	0.54	ND*	0.54
Wrapping Machine Op	0.88	0.52	1.40
Relief Man	0.23	ND	0.23
Lead Man	3.75	4.86	8.61
Foreman	0.85	0.81	1.66
On Third Deck Above Coater	8.02	6.67	14.29

*ND - less than 0.34 mg/m^3
Note: Aromatic Hydrocarbons were not deteced in the samples

Table 95 FREE SILICA AIR CONCENTRATIONS

Type of Sample	Job or Location	Particulates mg/m^3	% Free mg/m^3	Free Silica mg/m^3	Evaluation Criteria	
					OSHA Standards mg of dust/m^3	NIOSH Proposed Criteria
Total Particulate	Coater Man	0.46	14.1	0.065	1.86	---
Respirable Particulate	Press Man	0.49	12.4	0.061	0.69	0.05 mg of free SiO_2/m^3
Total Particulate	Granule Man	28.82	6.4	1.843	3.58	---
Total Particulate	Granule Man	2.30	2.8	0.065	6.25	---
Respirable Particulate	Slate Man	1.16	4.8	0.057	1.47	0.05 mg of free SiO_2/m^3
Total Particulate	By Slate Bins	0.47	14.3	0.067	1.84	---

*Limit of Detection - 0.04 mg/sample
**The OSHA Standard for Silica-bearing dust is based on the % free silica in the sample and is calculated as follows:

TOTAL DUST $\frac{30}{\%\ \text{free}\ SiO_2 + 2}$ RESPIRABLE DUST $\frac{10}{\%\ \text{free}\ SiO_2 + 2}$

Table 96 FREE SILICA AND ASBESTOS BULK SAMPLE

Sample Number	Description	% Free Silica
1	Light Brown Granules	26
2	Green Granules	25
3	Headlap Granules	30
4	Tan Granules	28
5	Rep Granules	30
6	White Granules	29
7	Dark Brown Granules	32
8	Mica	9
9	Talc	0.2
10	Coo Sand	60
		% Asbestos
9	Talc	None detected

Table 97 SPECIFIC POLYNUCLEAR AROMATIC HYDROCARBON AIR CONCENTRATIONS

Wrapping Machine Operator Job or Location	Benzo(a)pyrene ng/m^3*	Benz(a)anthracene ng/m^3	Chrysene ng/m^3	Fluoranthene ng/m^3	Pyrene ng/m^3
Saturator Man	ND**	ND	ND	ND	ND
Coater Man	ND	ND	ND	ND	ND
Coater Man	ND	ND	ND	ND	ND
Press Man	ND	ND	ND	ND	ND
Press Man	ND	ND	ND	ND	211
Wrapping Machine Operator	ND	ND	56	47	ND
Lead Man	ND	ND	ND	46	ND
Foreman	ND	ND	ND	ND	ND
1st Deck Above Coater	187	43	167	324	239
3rd Deck Above Coater	114	273	222	647	664
Bulk Air Sample Collected in the Saturator	3235	***	2059	9190	6985

*ng/m^3 - Nanograms of substance per cubic-meter of air
**ND - Not Detectable
***Due to Interferences the benz(a)anthracene could not be determined

On the basis of this study the following recommendations were made:

- Since asphalt fumes escape through the open doors of the cooling loop enclosure, these doors should be kept closed so all the makeup air will be brought into the enclosure through the designed openings.

- Local exhaust ventilation should be installed over the coater and press equipment. The use of this system should prevent the asphalt fumes from being emitted to the general work area.

- All leaks and transfer points in the slate, talc, and sand handling system should be identified. Dust emissions should be reduced through the use of improved maintenance, enclosures and/or local exhaust ventilation.

- Compressed air should not be used to blow dust from equipment; vacuuming is preferred. If the materials cannot be removed except by the use of blow down, a NIOSH-certi- fied respirator for use with those materials should be worn by individuals conducting the job.

- Whenever a worker enters a saturator, he should be required to wear either a NIOSH-certified supplied-air respirator or a NIOSH-certified respirator consisting of a dust, fume and mist pre-filter in combination with an organic vapor cartridge. Eye protection is also suggested.

- Whenever a worker performs work on the decks above the coater, he should wear a NIOSH-certified respirator consisting of a dust, fume and mist pre-filter in combination with an organic vapor cartridge.

- Based on other roofing firms using fibrous glass, it is anticipated that the airborne concentrations of fibrous glass would be less than the evaluation criterion. Employees would still be subjected to the fibrous glass particles which will produce an itching and irritation of the skin. Whenever fibrous glass is run, disposable coveralls are suggested for use by the workers. The sleeves, legs and neck openings should be taped tightly against the skin. It is also desirable to change and wash the clothing worn under the coveralls at the end of each shift. Showering after the shift is also recommended.

- Formaldehyde levels should be measured in the fibrous glass matte production building, in the rolled fibrous glass feed location of the roofing line, during the splicing operation, and at the coater area. The local exhaust system to be provided over the coater should control the formaldehyde as well as the asphalt fumes.

- A bulk sample of Coo sand indicates that it contains 60% of free silica. Based on this analysis, employees who work in the press area and who dump the sand should be evaluated for their exposure to free silica.

- Until such time that excessive exposures can be reduced by the use of engineering controls, individuals who are exposed to these substances should wear NIOSH-certified respirators. Whenever respirators are used, a respirator program that provides for proper selection, fitting, cleaning, maintenance, etc., in compliance with respirator usage standards, must be followed.

- Employees who may be exposed to fibrous glass, ashphalt fumes, free silica and high concentrations of dusts should be provided the following medical surveillance:

  a. Comprehensive medical and work histories with special emphasis directed towards evidence of acute or chronic skin conditions and pulmonary disease and prior exposures in dusty occupations such as those involving exposure to silica, coal dust, and asbestos.

  b. Physical examinations giving particular attention to the skin and respiratory system. Examinations should include simple tests for dermographism, and pulmonary function testing when considered to be appropriate by the responsible physician. Eye examination should also be considered when appropriate.

  c. During examinations, applicants or employees having medical conditions which would be directly or indirectly aggravated by exposure to fibrous glass, free silica, dust and asphalt fumes, should be counseled on the increased risk of impairment of their health from working with these substances.

  d. Those employees exposed to excessive concentrations of free silica should have preemployment chest X-rays, repeated at least once every three years thereafter.

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APPENDIX A

CHEMICAL PROFILES

CHEMICAL PROFILES

This appendix presents chemical profiles for those chemical species identified in Sections 4, 5 and 6. While some of these species are important in terms of both occupational exposure (as process and waste chemicals) and environmental release (emission, effluent and solid waste chemicals), many are known to be significant in terms of only one or the other of these areas of research. This appendix identifies those chemicals which are significant in terms of these areas of research.

Many process or waste chemicals have been identified in the NOHS walk-through database. In addition, toxic, nonconventional and priority pollutants in effluent streams have been identified from other sources. For these species, the following minimum information (if available) has been profiled:

- Occurrence
- Registry of Toxic Effects of Chemical Substances (RTECS) Number
- Permissible Air and Water Concentrations

For those chemical species determined to be significant in terms of occupational exposure, the following additional information has been profiled:

- Synonyms
- Description (including hazard or toxicity information)
- Properties (melting point, boiling point, specific gravity, solubility)

For certain chemical species known to be particularly hazardous to workers, additional items of information are profiled. These items are:

- Symptoms
- Target Organs
- Routes of Entry
- Protective Equipment
- Respirator Requirements
- First Aid and Medical Surveillance
- Leaks, Spills, and Waste Disposal Information

The selection of chemicals for which this additional information is profiled is based on several criteria. Many of these agents may be considered potential hazards because of their known toxic effects and the existence of Federal standards limiting work place exposure, recommended NIOSH and ACGIH exposure levels, and their occurrence in the NOHS walk-through data base (Table 57) at greater than 2% of workers exposed. Other chemicals are included because of their widespread use or occurrence in manufacturing operations and because of the resulting actual or anticipated chronic worker exposure. Some of these agents may not produce specific toxic effects but may be considered potentially hazardous due to their ability to produce allergic reactions or due to their possible presence in the work place as respirable dusts.

Data presented in this appendix are based on material which has been extracted from standard sources of information on toxicology and hazardous materials and from relevant NIOSH criteria documents. These data have been supplemented by material from research literature obtained during the literature search. Although many chemicals, such as general purpose solvents, are not directly related to the manufacture of paper, they are included in the Chemical Profiles since they are identified by the NOHS walk-through data base. For these chemicals, the nature of their occurrence in the industry is often given as "NOHS walk-through", since a definitive occurrence may not be documented in the research literature.

A reference code has been created to accompany the occurrence characteristics of each chemical. This code has been developed to label which study area number(s) apply to a given chemical, as well as which one(s) of the following occurrence characteristics apply to a given chemical: (1) process chemical, (2) pollutant chemical, (3) by-product chemical, (4) maintenance chemical. The form of the code is given as:

A.B

where A is a study area number and B is the characteristic. Where two characteristics occur, B may be a two digit number (i.e., 9.24 applies to a chemical used as a maintenance chemical in papermaking which also occurs as a pollutant chemical). Many chemicals occur widely through- out the entire pulp and papermaking industry. For these chemicals, the study area (A) is indicated with a hyphen (-). For many chemicals occurring in the NOHS walk through, no code is given since study area and occurrence characteristics are unknown.

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ABIETIC ACID

(-.2)

Occurrence
- Final effluent

Description
- Insoluble in water, combustible, low toxicity (active ingredient in rosin; obtained from pine resin or tall oil)

Registry Toxic Chemicals Number
- TP8580000

ACETIC ACID

(5.3)
(9.1)

Occurrence
- By-product of NSSC pulping
- Dye solvents

Synonym(s)
- Glacial Acetic Acid
- Methane Carboxylic Acid
- Ethanoic Acid
- Vinegar Acid
- Ethylic Acid

Description
- Colorless liquid or solid with a strong vinegar-like odor, soluble in water

Boiling Point: 117.8°C
Melting Point: 16.7°C
Specific Gravity: 1.0492

Permissible Exposure Limits in Air
- 10 ppm (25 mg/m^3) TWA ACGIH
- STEL 15 ppm ACGIH (37 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 1000 ppm

Registry Toxic Chemicals Number
- AF1225000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Conjunctivitis
- Lacrimation
- Nose/nasal irritation
- Bronchitis
- Sensitization
- Dental degeneration
- Cyanosis
- Pulmonary edema
- Eye burning and pain
- Skin burn
- Pulmonary burn

- Respiratory distress
- Cough
- Dyspnea
- Erythema
- Visual disturbance
- Vomiting
- Diarrhea
- Abdominal spasm

Target Organs

- Respiratory system
- Skin
- Eyes
- Teeth
- Lungs
- Gastrointestinal area

Protective Equipment Requirements

- Prevent any possibility of liquid contact
- Inform persons handling contaminated clothing of hazardous properties of substance
- Wear gloves

Work Clothing Should Be Changed Daily

- If there is any possibility that clothing may be contaminated

Remove Clothing

- Promptly if it is non-impervious and contaminated

Wear Eye Protection to Prevent

- Any possibility of eye contact (faceshield or vented goggles)

The Following Equipment Should Be Available

- Eyewash if liquids containing greater than 5% contaminant is present
- Drench if liquids containing greater than 50% contaminant present

Respirator Selection (Upper Limit Devices Permitted)

- 500 ppm
  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister
  - Self-contained breathing apparatus with full facepiece
- 1000 ppm
  - Type C supplied-air respirator with full facepiece operated in pressure demand or other positive pressure mode or with full facepiece, helmet or hood operated in continuous flow mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes wet

First Aid

- If acetic acid gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If acetic acid gets on the skin, immediately wash with soap or mild detergent and water. If this chemical soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- When the chemical has been swallowed, do not induce vomiting. Remove by gastric lavage and catharsis.

Medical Surveillance

- Physician exam
- Electrocardiogram
- Industrial exposure history
- Respiratory history
- Pulmonary functions
- EKG recommended if employee to wear full-face respirator
- Urinalysis
- 14 by 17 chest P.A. X-ray
- Pre-placement and annual exams
- Skin exam
- Vision test
- Blood chemistry

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Ventilate to disperse fumes
- To evaporate, use fume hood
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- Add caustic soda
- Apply water spray to knock down vapors
- Vapor knockdown waster is corrosive and should be contained

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- If body contact necessary, wear full protective gear

Waste Disposal Methods

- Atomize in suitable safe combustion chamber
- Dilute to neutralize, add caustic soda, then flush down drain
- Do not dump unneutralized substance in sewer due to explosivity
- Collect solid substance in most safe way for reclamation
- Allow to melt and collect in safe way
- Dissolve in flammable solvent and atomize in suitable combustion chamber equipped with proper effluent gas cleaning device

ACETONE

(-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- 2-Propanone
- Dimethyl ketone
- Ketone propane
- Methyl ketone
- Dimethylformamide
- Dimethylketal
- Pyrocetic acid
- Pyrocetic ether

Description
- Colorless volatile liquid with fragrant mintish odor, combustible

Boiling Point: 56.2°C

Solubility in Water at 20°C: greater than 100 g/100 ml

Melting Point: -94.3°C

Specific Gravity: 0.792

Permissible Exposure Limits in Air
- 1000 ppm (2,400 mg/m^3) OSHA
- 750 ppm (1,780 mg/m^3) TWA ACGIH
- STEL 1000 ppm (2,375 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 20,000 ppm

Registry Toxic Chemicals Number
- AL3150000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact
- Skin absorption

Symptoms
- Keratitis
- Nasal irritation
- Mucous membrane irritation
- Headache
- Dizziness
- Dermatitis
- Central nervous system depression
- Irritation of eyes(s)
- Irritation of skin
- Pulmonary irritation
- Erythema
- Cough
- Weakness
- Narcosis
- Pharyngitis
- Bronchitis
- Eczema
- Anesthesia
- Dyspnea

- Unconsciousness
- Central nervous system depression and irritability

Target Organs
- Respiratory system
- Lungs
- Eyes
- Skin
- Central nervous system
- Mucous tissue

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
- Any possibility of eye contact

Work Clothing Should Be Changed Daily
- If clothing is contaminated

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 500 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
- 20,000 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Supplied-air respirator with full facepiece
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated

First Aid
- If acetone gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial

respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- If the chemical gets on skin, wash with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- When this chemical has been swallowed, do not induce vomiting. Remove by gastric lavage and catharsis.

Medical Surveillance

- Physician exam
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
  - With emphasis on glucose
- CBC
- 14 by 17 chest P.A. X-ray
- Urinalysis
- Vision test
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions
- CNS tests (peripheral neuropathy)
- Medical warnings for refusal of medical exam

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- Remove ignition sources
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ACETYLENE

Occurrence
- NOHS walk-through

Synonym(s)
- Ethyne
- Welding gas

Description
- Carbide-smelling, clear gas, sometimes smells likeacetone because shipped in cylinders with acetone,combustible, asphyxiant

Boiling Point: -84°C

Solubility in Water, g/100 g water at 20°C: 1.7%

Melting Point: -81.8°C

Specific Gravity: 0.91

Permissible Exposure Limits in Air
- 2500 ppm 10-hour TWA NIOSH

Registry Toxic Chemicals Number
- A09600000

Route of Entry into Body
- Inhalation

Symptoms
- Asphyxia
- Narcosis
- Headache
- Nausea

Target Organs
- Lungs
- Eyes

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
- Any possibility of eye contact

Employee Should Wash
- Promptly when skin becomes contaminated

Work Clothing Should Be Changed Daily
- After work shift if contaminated

Remove Clothing
- Promptly if it is non-impervious and contaminated

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 2500 ppm (NIOSH recommends)
  - Supplied-air respirator
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode or continuous flow mode

First Aid
- If a person breathes in large amounts of acetylene, move the exposed person to fresh air at once. Other measures are usually unnecessary.

Medical Surveillance
- Physician exam
- General medical history
- Industrial exposure history
- Respiratory history
- Pulmonary functions
- Vision test
- EKG recommended if employee to wear full-face respirator

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If liquid, use paper towels to absorb small quantities
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- Keep material out of water sources and sewers
- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors
- Attempt to stop leak if without hazard

ACROLEIN (9.1)

Occurrence
- Biocide and slime control agent

Synonym(s)
- Acrylic Adlehyde
- Propenal
- Allyl aldehyde
- Aqualine
- NSC 8819
- 2-Propen-1-al

Description
- Clear, colorless to yellow liquid with piercing, disagreeable odor, eye irritant, carcinogen suspect

Boiling Point: 51.6°C

Solubility in Water g/100 g water at 20°C: 22%

Melting Point: 87°C

Specific Gravity: 0.8427

Permissible Exposure Limits in Air
- 0.1 ppm (0.25 mg/m^3) TWA OSHA
- STEL 0.3 ppm ACGIH (0.8 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 5 ppm

ACRYLAMIDE (9.1)

Occurrence
- Sizing and adhesive agent
- Component of synthetic wet-end adhesives
- Component of acrylamide polymer resins

Synonym(s)
- Propenamide
- Acrylamide monomer
- Acrylic amide

Description
- Colorless solid

Boiling Point: 213°C (Decomposes)
Solubility in Water, g/100 g water at 20°C: 216%
Specific Gravity: 1.122
Melting Point: 83.9°C

Permissible Exposure Limits in Air
- 0.3 mg/m^3 TWA (10-hour) OSHA and NIOSH
- 0.3 mg/m^3 (Skin) ACGIH
- STEL 0.6 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- AS3325000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Ataxia
- Numbness of extremities
- Paresthesia
- Fatigue
- Cachexia
- Sweating of extremities
- Lassitude
- Dysarthia
- Myotonia
- Infectious to humans

Target Organs
- Central nervous system
- Peripheral nervous system
- Skin
- Eyes

Protective Equipment Requirements
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Prevent repeated or prolonged skin contact
- Provide container to store clothing untill laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing Should Be Changed Daily
- If there is any possibility that clothing may be contaminated

Remove Clothing
- Immediately if it is contaminated

Wear Eye Protection to Prevent
- Reasonable probability of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 15 mg/m^3
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 600 mg/m^3
  - Type C supplied-air respirator with full facepiece, helmet, or hood, operated in pressure demand, positive-pressue or continuous flow mode
- Escape
  - Gas mask with organic vapor canister
  - Self-contained breathing apparatus with full facepiece
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If acrylamide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If the solid chemical gets on the skin, dust it off immediately and flush contaminated skin with water. If it penetrates clothing, promptly remove clothing and flush skin with water. Get medical attention immediately.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. When breathing is difficult, properly trained personnel may assist the affected person by administering 100% oxygen. Keep affected person warm and at rest. Get medical attention as soon as possible.
- When this chemical has been swallowed, get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- CBC

- 14 by 17 chest P.A. X-ray
- Urinalysis
- Vision test
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/dust
- To evaporate, use fume hood
- If liquid, use paper towels to absorb small quantities

Personal Danger Situation Protection
- Avoid breathing vapors or dust
- Keep upwind
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus
- If body contact necessary, wear full protective gear
- Do not handle broken packages without protective equipment

Waste Disposal Methods
- Mix large quantities with flammable liquid and atomize in suitable combustion chamber equipped with proper effluent gas cleaning device
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ACRYLIC ACID (9.1)

Occurrence
- Retention aid (monomer component of acrylic resin)

Synonym(s)
- Propenoic acid
- Ethylene carboxylic acid
- Vinylformic acid

Description
- Colorless liquid, acrid odor

Melting Point: 12°C-14°C
Boiling Point: 141°C
Permissible Exposure Limits in Air
- 10 ppm (30 mg/m^3) TWA ACGIH

ACRYLIC RESIN (9.1)

Occurrence
- Binding agent
- Adhesive

Description
- Thermoplastic polymer or copolymer of acrylic acid or acrylonitrile. Polymer solutions or aqueous emulsions are forms generally used.

ACRYLONITRILE (9.1)

Occurrence
- Starting material for acrylic resins

Synonym(s)
- AN
- Vinyl cyanide
- Acrylon
- ENT 54
- Propene nitrile
- TL 314
- Ventox
- Millers fumigrain
- Cyanoethylene

Description
- Colorless to pale yellow liquid with a pungent odor, combustible, carcinogen and teratogen suspect

Boiling Point: 77.3°C-77.4°C

Specific Gravity: 0.8004 (25°C)

Permissible Exposure Limits in Air
- 2 ppm (4.5 mg/m^3) ACGIH

Immediately Dangerous to Life or Health
- 4 ppm

ALGIN

Occurrence
- NOHS walk-through

Description
- Polysaccharide found in brown algae

ALKENYL SUCCINIC ANHYDRIDE (9.1)

Occurrence
- Sizing agent

ALKYL DIMETHYLBENZYLAMMONIUM CHLORIDE (9.1)

Occurrence
- Biocide/slime control agent

ALKYL KETENE DIMER (9.1)

Occurrence
- Sizing agent

ALUMINUM HYDROXIDE (9.1)

Occurrence
- Paper coating/pigment filler

Synonym(s)
- Alumina trihydrate
- Aluminum hydrate
- Hydrated alumina
- Hydrated aluminum oxide

Description
- White crystalline powder, balls, or granules, insoluble in water

Specific Gravity: 2.42

ALUMINUM OXIDE (9.1)

Occurrence
- Pigment filler/coating

Synonym(s)
- Activated aluminum oxide
- Alumina
- Brockman, aluminum oxide
- Alundum 600
- Dialuminum trioxide
- Dispal alumina
- Aluminum sesquioxide
- Alcoa F 1

Description
- White powder or grains, noncombustible, insoluble in water

Boilingn Point: 3500°C
Melting Point: 2030°C
Specific Gravity: 4.0 (20°C/4°C)

Permissible Exposure Limits in Air
- 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- BD1200000

Route of Entry into Body
- Inhalation
- Ingestion

Symptoms
- Eye irritation and pain
- Pulmonary irritation
- Cough
- Respiratory distress
- Emphysema

- Mucous membrane irritation
- Bronchitis

Target Organs
- Respiratory system
- Lungs
- Eyes
- Mucous tissue

Protective Equipment Requirments
- Prevent repeated or prolonged skin contact
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent

Advise:
- Any possibility of eye contact

Work Clothing Should Be Changed Daily

Advise:
- After work shift if contaminated

The Following Equipment Should Be Available

Advise:
- Eyewash

Respirator Selection (Upper Limit Devices Permitted)
- In general
  - High efficiency particulate respirator with full facepiece
- High Levels
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:
- At the end of each work shift

First Aid
- If aluminum oxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately wash skin with soap or mild detergent and water.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
Advise:
- EKG recommended if employee to wear full-face respirator
- General medical history
- Industrial exposure history
- Pre-placement and annual exams
- Pulmonary functions
  - Emphasis on chronic respiratory disease
  - Medical warning for refusal of medical exam

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse dust
- Sweep onto paper and dispose of in small packages by burning in safe place such as combustion chamber

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing dust
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
Advise:
- Collect solid substance in most safe way for reclamation
- Place in secured sanitary landfill
- Dilute with large quantities of water and flush into sewer

ALUMINUM PHOSPHATE

Occurrence
- NOHS walk-through

Synonym(s)
- Alumin orthophosphate

Description
- White crystals, insoluble in water. Solution is corrosive to tissue.

Specific Gravity: 2.566
Melting Point: 1500°C

ALUMINUM STEARATE

Occurrence
- NOHS walk-through

Synonym(s)
- Aluminum tristearate

Description
- White powder, insoluble in water, nontoxic

Specific Gravity: 1.070
Melting Point: 115°C

ALUMINUM SULFATE (9.1)

Occurrence
- Used to precipitate dissolved rosin for paper sizing and as retention aid
- Used for pulp stock pH control, pitch control and waste treatment

Synonym(s)
- Alum
- Pearl alum
- Filter alum
- Paper makers' alum
- Sulfuric acid, alumunium salt

Description
- White crystals, sweet taste, nontoxic and noncombustible. Skin irritant, low toxicity, ingestions of high concentrations produces gastroenteritis, kidney damage.

Specific Gravity: (Crystals) 2.71
(Octadecahydrate) 1.62

Melting Point: (Crystals) 770°C Decomposes
(Octadecahydrate) 86.5°C Decomposes

Registry Toxic Chemicals Number
- BD1700000

ALUMINUM SULFIDE (4.1)
(5.1)

Occurrence
- Preparation of hydrogen sulfide (as source of sulfur)

Description
- Yellowish-gray lumps, odor of hydrogen sulfide, decomposes to form gray powder in moist air, decomposed by water to form hydrogen sulfide, toxic by ingestion, irritant to skin and tissue.

Specific Gravity: 2.02
Melting Point: 1100°C

AMINOETHYL ACRYLATE COPOLYMER (9.1)

Occurrence
- Retention aid

AMINOPOLYAMIDE-EPICHLOROHYDRIN RESIN (9.1)

Occurrence
- Creping aid

AMINOPOLYAMIDES (9.1)

Occurrence
- Wet-strength/dry-strength agent
- Creping aid

AMMONIA

(4.12)
(5.12)
(9.12)

Occurrence
- Final effluent (sulfite processes)
- Ingredient in coatings and adhesives
- Ammonia-base sulfite (ammonium hydroxide solution as source of base) and NSSC pulping

Synonym(s)
- Anhydrous Ammonia
- Am-Fol
- Ammonia Gas
- Ammonium Hydroxide

Description
- Colorless gas with a penetrating, pungent, suffocating odor. It can be a liquid under pressure

Boiling point -33.3°C

Solubility in water, g/100 g water at 20°C: 51%

Melting Point: -77.7°C

Specific Gravity: 0.77

Permissible Exposure Limits in Air
- 50 ppm 8-hour TWA (35 mg/m^3)
- 50 ppm 5-minute ceiling NIOSH
- 25 ppm ACGIH (18 mg/m^3)
- STEL 35 ppm ACGIH (27 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 500 ppm (348 mg/m^3)

Registry Toxic Chemicals Number
- B00875000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or Eye Contact

Symptoms
- Eye irritation
- Nose irritation
- Dry throat
- Dyspnea
- Bronchospasm
- Respiratory distress
- Pulmonary edema
- Pink frothy sputum
- Skin burn
- Vesiculation
- Chronic lung disease
- Cough
- Severe breathing disturbance
- Keratitis
- Bronchitis
- Blindness

Target Organs
- Lungs
- Respiratory system

- Eyes

Protective Equipment Requirements
- Prevent any possiblity of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing should be Changed Daily
- If there is any possibility that clothing may be contaminated, leaving clothing and equipment for decontamination and disposal

Remove Clothing
- Promptly if it is non-impervious and contaminated

The Following Equipment should be Available
- Quick drench, eyewash
- Water fountain prohibited in work area

Respirator Selection (Upper Limit Devices Permitted)
- 500 ppm
  - Gas mask, chin-style or front- or back-mounted with ammonia canister
  - Supplied-air respirator, with full facepiece, helmet or hood
  - Self-contained breathing apparatus, with full facepiece
  - Supplied-air suits to prevent skin contact and auxiliary self-contained breathing apparatus
- 300 ppm
  - Chemical cartridge respirator with full facepiece
- 100 ppm
  - Chemical cartridge respirator
  - Supplied-air respirator operated in pressure demand or positive-pressure mode
  - Self-contained breathing apparatus
- Escape
  - Gas mask
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated
- Wash hands, arms, face, neck at each departure from work

First Aid
- If ammonia gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical
- If this chemical gets on skin, immediately flush with water. If it penetrates clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- If the chemical has been swallowed, DO NOT induce vomiting. Get medical attention immediately.

Medical Surveillance

- Physician examination
- General medical history
- Industrial exposure history (emphasis on chronic respiratory disease)
- Respiratory history
- Vision test
- 14 by 17 chest P.A. X-ray
- Pulmonary functions
- Skin exam
- Pre-placement and annual exams
- X-ray (repeat when pulmonary results or other respiratory test indicated)
- Urinalysis
- EKG recommended if employee to wear full-face respirator

Leaks and Spill Procedures

- Apply water spray to knockdown vapors
- Vapor knockdown water is toxic and should be contained
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- If liquid, allow to evaporate

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may hve contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Atomize in suitable safe combustion chamber

AMMONIUM BROMIDE

Occurrence

- NOHS walk-through

Description

- Colorless cyrstals or yellowish white powder, soluble in water, somewhat hygroscopic, noncombustible. Moderately toxic by ingestion and inhalation.

Specific Gravity: 2.43

AMMONIUM CHLORIDE (9.1)

Occurrence

- Starting material for urea-formaldehyde resins

Synonym(s)
- Amchlor
- Ammoneric
- Ammonium muriate
- Darammon
- Sal Ammonia
- Sal Ammoniac
- Salammonite
- Salmiac

Description
- White crystalline solid, odorless

Solubility in Water: 30 g/100 ml
Melting Point: 338°C (Decomposes)
Specific Gravity: 1.54
Permissible Exposure Limits in Air
- 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH

AMMONIUM PHOSPATE, DIBASIC (9.1)

Occurrence
- Flame retardant

Synonym(s)
- Ammonium phosphate, secondary
- Diammonium hydrogen phosphate
- Diammonium phosphate
- DAP

Description
- White crystals or powder, soluble in water, noncombustible, low toxicity

Specific Gravity: 1.619

AMMONIUM PHOSPHATE, MONOBASIC

Occurrence
- NOHS walk-through

Synonym(s)
- Ammonium acid phosphate
- Ammonium biphosphate
- Ammonium dihydrogen phosphate
- Ammonium phosphate, primary

Description
- Brilliant white crystals or powder, moderately soluble in water, noncombustible, low toxicity

Specific Gravity: 1.803

AMMONIUM STEARATE (9.1)

Occurrence
- Sizing agent

Description
- Tan, wax-like solid, free from ammonia odor, combustible, soluble in boiling water

Specific Gravity: 0.89 (22°C)
Melting Point: 73°C-75°C

AMMONIUM SULFAMATE (9.1)

Occurrence
- Flame retardant

Synonym(s)
- Anmate herbicide
- Amicide
- Ammate X
- AMS
- Ikurin

Description
- Colorless, odorless solid, nonflammable

Boiling Point: 160°C (Decomposes)
Solubility in Water, g/100 g water at 20°C: 200%
Melting Point: 130°C
Permissible Exposure Limits in Air
- 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH

AMMONIUM SULFATE

Occurrence
- NOHS walk-through

Description
- Brownish-gray to white crystals (according to degree of purity), soluble in water, nonflammable

Specific Gravity: 1.77
Melting Point: 5.13°C

ANETHOLE

Occurrence
- NOHS walk-through

Synonym(s)
- Anise camphor
- Para-methoxypropenylbenzene
- Para-propenylanisole

Description
- White crystals with sweet taste, odor of oil of anise

Specific Gravity: 0.983-0.987
Melting Point: 22°C-23°C

ANIMAL GLUE (9.1)

Occurrence
- Binding agent and adhesive
- Sizing agent
- Creping aid

Description
- Protein derived from animal bones, skins, etc., soluble in hot water after treatment with acid and alkali

ANISIDINES (9.1)

Occurrence
- Azo dye intermediates

Synonym(s)
- ortho-Methoxyaniline
- para-Methoxyaniline

Description
- Colorless to pink liquid (o-isomer) or reddish-brown solid (p-isomer), amine (fishy) odor, insoluble in water. Toxic by inhalation and skin absorption, strong irritant

Specific Gravity: (ortho) 1.097 (20°C)
(para) 1.089 (55°C/55°C)

Boiling Point: (ortho) 225°C
(para) 242°C

Permissible Exposure Limits in Air
- 0.1 ppm (0.5 mg/m^3) (skin)

Immediately Dangerous to Life or Health Concentration
- 50 mg/m^3

ANTHRACENE (2.2)
(4.2)
(10.2)

Occurrence
- Component of asphalt fume
- Final effluent (dissolving kraft and sulfite processes and BCT kraft process)

Synonym(s)
- Polynuclear aromatic hydrocarbons
- A

Description
- Known carcinogen, combustible, insoluble in water

Permissible Concentrations in Water
- Preferably zero (EPA)

Permissible Exposure Limits in Air
- 0.2 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- CA9350000

ANTHRAQUINONE

(2.1)
(3.1)
(9.1)

Occurrence
- Kraft and soda pulping modification
- Dyes

Description
- Yellow needles, insoluble in water, combustible, low toxicity

Specific Gravity: 1.419-1.438
Melting Point: 286°C
Boiling Point: 379°C-381°C

ANTIMONY DIOXIDE

Occurrence
- NOHS walk-through

ANTIMONY DITHIOCARBAMATE

Occurrence
- NOHS walk-through

ANTIMONY TRIOXIDE

(9.1)

Occurrence
- Flame retardant

Synonym(s)
- Antimony white
- Oxide of antimony
- Antimony sesquioxide
- G.E. material D4C22

Description
- White crystals, odorless, tasteless, insoluble in water, carcinogen suspect

Boiling Point: 1533.3°C
Melting Point: 655°C
Specific Gravity: 5.67
Permissible Exposure Limits in Air
- 0.5 mg/m^3 ACGIH

Immediately Dangerous to Life or Health Concentration
- 80 mg/m^3

ARGON

(-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Argon-40

Description
- Colorless, odorless, tasteless, inert gas, noncombustible, asphyxiant, slightly soluble in water

Boiling Point: -185.8°C
Specific Gravity: 1.38

ARSENIC (2.2)

Occurrence
- Oil-fired power boilers (particulate)

Description
- Carcinogen

Permissible Exposure Limits in Air
- 0.004 mg/m^3 8-hour TWA OSHA
- 0.01 mg/m^3 8-hour TWA NIOSH
- 0.2 mg/m^3 TWA ACGIH

ASBESTOS (9.1) (10.1)

Occurrence
- Pigment filler/coating
- Retention aid
- Filler in building board
- Pitch control agent
- Component of paper machine felt
- Component of building paper

Synonym(s)
- Chrysotile
- Amosite
- Crocidolite
- Tremolite
- Anthophyllite
- Actinolite

Description
- Variable mineral to type of asbestos and to area mined, white to different colors of light ranges, (mixed with other minerals) noncombustible, insoluble in water, carcinogen suspect

Boiling Point: 2230°C
Melting Point: 1723.3°C
Specific Gravity: 2.5
Permissible Exposure Limits in Air
- 2 fibers not greater than 5 microns diam/cc or equiv. in length
- 10 fiber/cc ceiling

Registry Toxic Chemicals Number
- CI6475000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Skin irritation
- Pulmonary cancer
- Dermatitis
- Pulmonary fibrosis
- Pleural thickening
- Mesothelioma
- Pulmonary irritation

Target Organs
- Respiratory system
- Lungs
- Gastrointestinal system

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

Work Clothing Should Be Changed Daily
- After work shift if contaminated

Remove Clothing
- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- In general
  - Gas mask with dust and mist filter, except quarter-mask, except single-use
- Firefighting
  - Self-contained breathing apparatus
  - Supplied-air respirator with full facepiece
  - Type C supplied-air respirator, operated in pressure demand or positive-pressure or continuous flow mode

Employee Should Wash
- At the end of each work shift

First Aid
- If asbestos gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash with soap or mild detergent and water. Get medical attention promptly.

- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, get medical attention immediately. If medical attention is not available get the person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. Do not make an unconscious person vomit.

Medical Surveillance
- Physician exam
- General medical history
- Industrial exposure history
- Respiratory history
- 14 by 17 chest P.A. X-ray
- UICC chest X-ray
- Pulmonary functions
- Pre-placement and annual exams
- Attention to smoking, alcohol, medication and exposure to carcinogens
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning
- Termination exam-30 day
- General cancer exam

Waste Disposal Methods
- Absorb in vermiculite, dry sand, earth or similar material, and place in sealed containers insecured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ASPHALT (10.12)

Occurrence
- Basis for sizing agents and adhesives

Description
- Black solid or viscous liquid and related fumes

Specific gravity: 1.0

Melting Point (turns to viscous liquid): 93C

Permissible Exposure Limits in Air
- 5 mg/m^3 (15 minute ceiling) OSHA
- STEL 10 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- CI9900000

Route of Entry into Body
- Inhalation
- Skin exposure

Symptoms
- Conjunctivitis
- Respiratory irritation

Target Organs
- Skin
- Respiratory system

Protective Equipment Requirements
- Prevent skin and eye contact
- Wear impervious gloves and boots
- Wear face shield

Respirator Selection
- Engineering controls shall be used to maintain concentrations below permissible exposure levels. NIOSH approved respirators shall be used:
  - (a) During the time required to install or test the necessary engineering controls.
  - (b) For operations such as nonroutine maintenance or repair activities causing brief exposure at concentrations above the environmental limit.
  - (c) During emergencies when concentrations of asphalt fumes may exceed the environmental limit

Medical Surveillance
- General medical history and updates

Waste Disposal Method
- Incineration

1,1'-AZOBISFORMAMIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Azodicarbonamide

Description
- Yellow powder, nontoxic

Specific Gravity: 1.65 (20°C/20°C)
Melting Point: greater than 180°C

BARIUM SULFATE (9.1)

Occurrence
- Pigment coating/filler (component of lithopone)

Synonym(s)
- Barytes (natural)
- Blancfixe (artificial, precipitated)
- Basofor
- Barite

Description
- White or yellowish odorless, tasteless powder, nontoxic and noncombustible, insoluble in water.

Specific Gravity: 4.25-4.5
Melting Point: 1580°C

Permissible Concentration in Air (as barium)
- 0.5 mg/m^3

Immediately Dangerous to Life or Health Concentration
- 250 mg/m^3

BENTONITE

(8.1)
(9.1)

Occurrence
- Deinking
- Pitch control agent

Synonym(s)
- Calcium bentonite
- Sodium bentonite

Description
- Colloidal clay (aluminum silicate) composed mainly of montmorillonite. Sodium bentonite has high swelling capacity in water; calcium bentonite has negligible swelling capacity. Substance is light to cream-colored impalpable powder, forming colloidal suspension in water, nontoxic and noncombustible

BENZ[a]ANTHRACENE

(10.2)

Occurrence
- Component of asphalt fume

Synonym(s)
- Polynuclear aromatic hydrocarbons
- BaA
- 1,2-Benzanthracene

Permissible Exposure Limits in Air
- 0.2 mg/m^3 ACGIH

BENZENE

(2.2)
(3.2)
(4.2)
(5.2)
(7.2)
(8.2)
(9.2)
(10.2)
(-.4)

Occurrence
- NOHS walk-through
- Final effluent

Synonym(s)
- Benzol
- Cyclohexatriene
- Coal Tar Naphtha
- Phenyl Hydride

Description
- Colorless liquid with an aromatic odor, combustible, carcinogen suspect

Boiling Point: 80.1°C

Solubility in Water, g/100 g water at 20°C: 0.18%

Melting Point: 5.5°C

Specific Gravity: 0.8790 (20°C/4°C)

Permissible Concentrations in Water
- 5,300 micrograms/l (freshwater, acute)
- 5,100 micrograms/l (saltwater, acute)
- Preferably zero (human)

Permissible Exposure Limits in Air
- 10 ppm (30 mg/m^3) ACGIH and NIOSH
- 1 ppm 8-hour TWA
- 5 ppm (15-minute ceiling)
- STEL 25 ppm (75 mg/m^3)

Immediately Dangerous to Life or Health
- 2000 ppm (6380 mg/m^3)

Registry Toxic Chemicals Number
- CY1400000

Route of Entry Into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Irritation of eyes, nose
- Respiratory distress
- Giddiness
- Headache
- Nausea
- Fatigue
- Anorexia
- Lassitude
- Dermatitis
- Seizure
- Abdominal cramps
- Hematopoietic change
- Bone marrow depression
- Leukopenia
- Leukemia

Target Organs
- Blood
- Central nervous system
- Skin
- Bone marrow
- Eyes
- Respiratory system

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Wear Eye Protection to Prevent
- Any possibility of eye contact

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
- Eyewash
- No food or drink in the work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 10 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 50 ppm
  - Self-contained breathing apparatus with full facepiece
  - Supplied-air respirator with full facepiece, helmet, or hood
- 1000 ppm
  - Supplied-air respirator
  - Type C supplied-air respirator, operated in pressure-demand, positive-pressure or continuous flow mode
- 2000 ppm
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode or with full facepiece, helmet, or hood, operated in continuous flow mode
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly with soap when skin becomes contaminated

First Aid
- If benzene gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, promptly wash with soap or mild detergent and water. If it soaks clothing, promptly remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If the chemical has been swallowed, do not induce vomiting. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- With emphasis on blood disease
- Blood cell morphology (differential)
- CBC
- Physician examination
- 14 x 17 chest P.A. X-ray
- Vision test
- Pulmonary functions
- Urinalysis
- Reticulocyte count

- Platelet count
- Skin exam
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- To evaporate, use fume hood
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Avoid breathing vapors
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- Absorb in vermiculite, dry sand, earth or similar material and then place in sealed containers in secured sanitary landfill

BENZIDINE (9.1)

Occurrence
- Component of azo dyes and pigments (Monoazo, Diazo, Triazo)

Synonym(s)
- 4,4'-Biphenyldiamine
- p-Diaminodiphenyl
- 4,4'-Diaminobiphenyl
- 4,4'-Diphenylenediamine
- Benzidine base

Description
- Crystalline solid, known carcinogen. All contact through inhalation, skin absorption or ingestion should be avoided.

BENZOIC ACID

Occurrence
- NOHS walk-through

Synonym(s)

- Carboxybenzene
- Benzenecarboxylic acid
- Phenylformic acid

Description

- White scales or needle crystals with odor of benzoin or benzaldehyde, slightly soluble in water, combustible, moderately toxic by ingestion

Specific Gravity: 1.2659
Melting Point: 121.25°C
Boiling Point: 249.2°C

BENZO[a]PYRENE

(2.2)
(10.2)

Occurrence

- Emission from sulfate recovery furnace (absorbed on particles in electrostatic precipitator)
- Component of asphalt fume

Synonym(s)

- Polynuclear Aromatic Hydrocarbons
- BAP
- Particulate Polycyclic Aromatic Hydrocarbons
- Polynuclear Organic Materials
- PAH

Description

- Yellowish, crystalline solid, carcinogen

Melting Point: 179°C
Boiling Point: 310°C-312°C (10 mm)
Permissible Exposure Limits in Air

- 0.2 mg/m^3 ACGIH

2-BENZOTHIAZOLETHIOL

Occurrence

- NOHS walk-through

Synonym(s)

- 2-Mercaptobenzothiazole

Description

- Pale yellow, monoclinic needles or leaflets, disagreeable odor, practically insoluble in water.

Density: 1.42
Melting Point: 180.2°C-181.7°C

1,2,3-BENZOTRIAZOLE

Occurrence

- NOHS walk-through

Synonym(s)

- Aziminobenzene
- Benzeneazimide

Description
- White to light tan, odorless, crystalline powder, slightly soluble in water, toxic by ingestion.

Boiling Point: 201°C-204°C (15 mm)

BIS-1,4-BROMOACETOXY-2-BUTENE (9.1)

Occurrence
- Biocide/slime control agent

2,6-BIS(DIMETHYLAMINOMETHYL)CYCLOHEXANONE (9.1)

Occurrence
- Preservative for pigments, adhesives

Specific Gravity: 0.95 (20°C)

BIS(2-ETHYLHEXYL)PHTHALATE (-.24) (-.4)

Occurrence
- Vacuum pumps
- Final effluent

Synonym(s)
- Dioctyl phthalate
- Di-sec-octyl phthalate
- Di(2-ethylhexyl)phthalate

Description
- Clear to slightly colored oily liquid, low toxicity. Teratogen suspect.

BIS(TRICHLOROMETHYL)SULFONE (9.1)

Occurrence
- Biocide/slime control agent

BORIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Boracic acid
- Orthoboric acid
- Hydrogen borate

Description
- Colorless, odorless scales or white powder, noncombustible, carcinogen suspect, toxic by ingestion, skin irritant in dry form

Solubility in Water, g/100 g water at 20°C: 4.9
Melting Point: 185°C (Decomposes)
Specific Gravity: 1.4347 (15°C)

BROMOFORM (7.2)

Occurrence
- Final effluent (paperboard from waste paper process)

Description
- Carcinogen

Permissible Exposure Limits in Air
- 0.5 ppm (5.0 mg/m^3) (skin or inhalation) ACGIH

Permissible Concentrations in Water
- 0.10 mg/l (drinking)
- Preferably zero (human health)

Registry Toxic Chemicals Number
- PB5600000

2-BROMO-4-HYDROXYACETOPHENONE (9.1)

Occurrence
- Biocide/slime control agent

2-BROMO-1-(4-HYDROXYPHENYL)-ETHANONE

Occurrence
- NOHS walk-through

2-BROMO-2-NITROPROPANE-1,3-DIOL (9.1)

Occurrence
- Biocide/slime control agent

BROMOTHYMOL BLUE (9.1)

Occurrence
- Acid-base indicator

Synonym(s)
- Dibromothymolsulfonphthalein

Description
- Shows color change from yellow to blue over pH range 6.0-7.6

2-BUTANONE

Occurrence
- NOHS walk-through

Synonym(s)
- Methyl ethyl ketone
- MEK
- Ethyl methyl ketone
- Methyl acetone

- Butanone
- Meetco

Description
- Clear liquid with mint-like, moderately sharp odor

Boiling Point: 79.6°C
Solubility in Water, g/100 g water at 20°C: 27%
Melting Point: -86.1°C
Specific Gravity: 0.805

Permissible Exposure Limits in Air
- 200 ppm (590 mg/m^3)ACGIH
- STEL 300 ppm (885 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 3,000 ppm

Registry Toxic Chemicals Number
- EL6475000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact
- Skin absorption

Symptoms
- Irritation of eyes(s)
- Irritation of nose
- Headache
- Dizziness
- Nausea
- Vomiting
- Dyspnea
- Euphoria

Target Organs
- Central nervous system
- Lungs
- Liver

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
Advise:
- Reasonable possibility of eye contact

Work Clothing Should Be Changed Daily
Advise:
- After work shift if contaminated

Remove Clothing
- Promptly if it is non-impervious and immediately if it is non-impervious and wet

The Following Equipment Should Be Available

Advise:

- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)

- 1,000 ppm
  - Chemical cartridge respirator with organic vapor cartridge and full facepiece
- 3,000 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:

- Promptly when skin becomes contaminated

First Aid

- If 2-butanone gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. Other measures are usually unnecessary.
- When the chemical has been swallowed, immediately get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Blood chemistry
- SGOT
- SGPT
- LDH
- GGTP
- CBC
- Blood cell morphology (differential)
- 14 by 17 chest P.A. X-ray
- EKG recommended if employee to wear full-face respirator

- Pulmonary functions
- Urinalysis
- Vision test

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep material out of water sources and sewers
- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors
- Attempt to stop leak if without hazard

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Atomize in suitable safe combustion chamber
- Add vermiculite or perlite to spill in at least equivalent weight to the spill quantity itself -- drain off water and burn in unconfined open combustion chamber equipped with effluent gas cleaning device
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

2-BUTOXYETHYLACETATE

Occurrence
- NOHS walk-through

BUTYL ACETATE

Occurrence
- NOHS walk-through

Synonym(s)
- N-butyl acetate
- Butyl ethanoate
- Acetic acid butyl ester

Description
- Colorless liquid or solid with a fruity odor

Boiling Point: 126.3°C

Solubility in Water, g/100 g water at 20°C: 0.68%

Melting Point: 38.3°C

Specific Gravity: 0.8826 (20°C/20°C)

Permissible Exposure Limits in Air
- 150 ppm (710 mg/m^3)
- STEL 200 ppm (950 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 10,000 ppm

BUTYL ALCOHOL

Occurrence
- NOHS walk-through

Synonym(s)
- 1-Butanol
- Propylcarbinol
- N-Butanol
- N-Butyl alcohol
- NBA
- Hydroxybutane
- CCS 203
- Methylolpropane

Description
- Colorless liquid with a strong, characteristic odor

Boiling Point: 118°C
Solubility in Water, g/100 g water at 20°C: 7.7%
Melting Point: -89°C
Specific Gravity: 0.8109

Permissible Exposure Limits in Air
- 100 ppm
- 50 ppm (150 mg/m^3) ceiling ACGIH

Immediately Dangerous to Life or Health Concentration
- 8,000 ppm

BUTYL BENZYL PHTHALATE (2.2)

(4.2)

Occurrence (5.2)
- Starting material in polyvinyl and cellulosic resins (7.2)
- Final effluent (8.2)

Synonym(s) (9.12)
- BBP (10.2)

Registry Toxic Chemicals Number
- TH9990000

1,2-BUTYLENE OXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- 1,2-epoxybutane

Description
- Colorless liquid, soluble in water. Toxic concentrations occur at room temperature.

Specific Gravity: 0.8312 (20°C/20°C)
Boiling Point: 63°C

2,3-BUTYLENE OXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- 2,3-epoxybutane

Description
- Decomposes in water. Toxic concentrations occur at room temperature.

Specific Gravity: (cis) 0.8266 (25°C/4°C)
(trans) 0.8010 (25°C/4°C)
Boiling Point: (cis) 59.7°C (742 mm)
(trans) 53.5°C (742 mm)

BUTYL STEARATE

Occurrence
- NOHS walk-through

Synonym(s)
- Butyl octadecanoate

Description
- Colorless, stable, oleaginous liquid, solidifies at about 19 C. Practically odorless, sometimes has faint fatty odor, insoluble in water, combustible

Specific Gravity: 0.855-0.860 (25°C/25°C)
Melting Point: 19.5°C-20.0°C
Boiling Point: 350°C

CADMIUM (2.2)

Occurrence
- Oil-fired power boilers (particulate)

Description
- Carcinogen

Permissible Exposure Limits in Air (dust)
- 0.2 mg/m^3 8-hour TWA
- 0.6 mg/m^3 (ceiling)
- 0.04 mg/m^3 TWA NIOSH
- 0.2 mg/m^3 (ceiling) NIOSH
- 0.05 mg/m^3 TWA ACGIH
- STEL 0.2 mg/m^3

CALCIUM ALUMINATE

Occurrence
- NOHS walk-through

Synonym(s)
- Tricalcium aluminate

Description
- Crystals or powder

Specific Gravity: 3.038 (25°C)

CALCIUM CARBONATE (2.13) (4.1) (9.1)

Occurrence
- Opacifying agent (filler)
- Source of lime in kraft pulping
- Calcium-base sulfite pulping

Synonym(s)
- Limestone

Description
- White powder or colorless crystals, tasteless and odorless, soluble in water, noncombustible

Specific Gravity: 2.7-2.95

Permissible Exposure Limits in Air
- 5 mg/m^3

CALCIUM CHLORIDE (9.1)

Occurrence
- Retention aid

Description
- White, deliquescent crystals, granules, lumps or flakes; all forms soluble in water, low toxicity

Specific Gravity (25°C): 2.15
0.835 (dihydrate)
1.71 (hexahydrate)

Melting Point: 772°C
260°C (hydrate)

Boiling Point: greater than 1600°C
30°C (hexahydrate)

CALCIUM FERRITE

Occurrence
- NOHS walk-through

CALCIUM HYDROXIDE (2.1) (3.1) (4.1) (5.1)

Occurrence
- Extraction stage in chemical bleaching
- Preparation of calcium hypochlorite (bleaching chemical)
- Possible calcium base for sulfite pulping

Synonym(s)
- Calcium hydrate
- Hydrate lime
- Caustic lime
- Slaked lime

Description
- Soft, white, crystalline powder, slightly soluble in water, toxic by inhalation, skin irritant

Melting Point: 580°C (dehydrates to calcium oxide)
Specific Gravity: 2.34
Permissible Exposure Limits in Air
- 5 mg/m^3 TWA ACGIH

Registry Toxic Chemicals Number
- EW2800000

CALCIUM HYPOCHLORITE

(2.1)
(3.1)
(4.1)
(5.1)
(9.1)

Occurrence
- Chemical bleaching; oxidizer and germicide

Synonym(s)
- Calcium oxychloride

Description
- White crystalline solid, decomposes in water. Toxic by ingestion, inhalation, skin absorption

Specific Gravity: 2.35
Boiling Point: 100°C (Decomposes)

CALCIUM MANGANESE OCTOATE

Occurrence
- NOHS walk-through

CALCIUM OXIDE

(2.3)
(4.1)

Occurrence
- Generated in kraft pulping process; used to convert sodium carbonate to sodium hydroxide; found in lime kiln, slaker and causticizer
- Calcium-base sulfite pulping

Synonym(s)
- Quicklime
- Calx
- Burnt lime
- Lime
- Unslaked Lime
- Calcia

Description
- Odorless white or greyish white lumps or granular powder, reacts with water to form calcium hydroxide

Boiling Point: 2850°C
Melting Point: 2570°C

Specific Gravity: 3.40

Permissible Exposure Limits in Air
- 5 mg/m^3 OSHA
- 2 mg/m^3 TWA ACGIH

Immediately Dangerous to Life or Health Concentration
- 250 mg/m^3

Registry Toxic Chemicals Number
- EW3100000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Eyes irritation
- Pulmonary irritation
- Vesiculation of skin
- Nose/nasal mucous membrane perforation
- Pneumonia
- Dermatitis
- Skin burn

Target Organs
- Respiratory system
- Skin
- Eyes

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing Should Be Changed Daily
- After work shift if contaminated

Remove Clothing
- Promptly if it is non-impervious and contaminated and immediately if it is non-impervious and wet

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 25 mg/m^3
  - Dust and mist respirator, with full facepiece when eye or facial irritation present
- 50 mg/m^3
  - Dust and mist respirator except single-use, except quarter-mask
  - Fumes or high-efficiency particulate respirator, with full facepiece when eye or facial irritation present
  - Supplied-air respirator, with full facepiece when eye or facial irritation present

  - Self-contained breathing apparatus, with full facepiece when eye or facial irritation present
- 250 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode
- Escape
  - High-efficiency particulate respirator with full facepiece
  - Self-contained breathing apparatus

Employee Should Wash

- Promptly when skin becomes contaminated and at the end of each work shift

First Aid

- If calcium oxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately flush with water. If irritation persists after washing, get medical attention immediately.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If the chemical has been swallowed and the person is conscious, immediately give him large quantities of water to dilute the chemical. Do not attempt to make the exposed person vomit. Get medical attention immediately.

Medical Surveillance

- Physician examination
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Urinalysis
- Vision test
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses/dust
- Immediately douse with water and cover with wet sand or dirt
- Add acetic acid to neutralize until vinegar odor detectable and then flush neutralized spill

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles

- Avoid breathing dust
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Collect solid substance in most safe way for reclamation
- Absorb in vermiculite, dry sand, earth or similar material and place in secured sanitary landfill
- Dilute with water and neutralize with hydrochloric acid
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls of overtopping, flooding or other spurious discharge required by EPA (RCRA).

CALCIUM PHOSPHATE, DIBASIC

Occurrence

- NOHS walk-through

Synonym(s)

- Dicalcium orthophosphate
- Bicalcium phosphate
- Secondary calcium phosphate

Description

- White, tasteless crystalline powder, odorless, slightly soluble in water, nontoxic and noncombustible

Specific Gravity: 2.306 (hydrate)

CALCIUM PHOSPHATE, MONOBASIC

Occurrence

- NOHS walk-through

Synonym(s)

- Calcium biphosphate
- Acid calcium phosphate
- Calcium phospate, primary
- Monocalcium phosphate

Description

- Colorless, pearly scales or powder, deliquescent in air, soluble in water, nontoxic and noncombustible.

Specific Gravity: 2.20

Melting Point: 200°C (Decomposes)

CALCIUM PHOSPHATE, TRIBASIC

Occurrence

- NOHS walk-through

Synonym(s)

- Calcium orthophosphate
- Tricalcium phosphate
- Precipitated calcium phosphate

- Tricalcium orthophosphate
- Tertiary calcium phosphate

Description
- White, odorless, tasteless crystalline powder, insoluble in water, nontoxic and noncombustible.

Specific Gravity: 3.18
Melting Point: 1670°C

CALCIUM RESINATE (9.1)

Occurrence
- Paper coating

Description
- Yellowish-white, amorphous powder or lumps, rosin odor, insoluble in water, dangerous fire risk

CALCIUM STEARATE (9.1)

Occurrence
- Paper coating

Description
- White powder, insoluble in water, low toxicity

Melting Point: 179°C

CALCIUM SULFATE (9.1)

Occurrence
- Pigment filler/coating

Synonym(s)
- Calcium sulfate
- Alabastar
- Terra alba
- Magnesia white
- CL 77231
- Selenite
- Dihydrate salt

Permissible Exposure Limits in Air
- 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH
- 5 mg/m^3 (nuisance dust)

Description
- White powder or colorless crystals, red, gray, blue tinge, noncombustible and nontoxic

Boiling Point: 163°C
Solubility in Water, g/100 g water at 20°C: 0.2
Melting Point: 1450°C
Specific Gravity: 2.32

CALCIUM SULFOALUMINATE (9.1)

Occurrence
- Pigment filler/coating

CAMPHOR (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- 2-Camphonone
- Synthetic camphor
- Gum camphor
- Laurel camphor

Description
- Colorless glassy solid with characteristic odor, combustible

Boiling Point: 207.2°C
Solubility in Water, g/100 g water at 20°C: 0.12%
Melting Point: 174°C-179°C
Specific Gravity: 0.99
Permissible Exposure Limits in Air
- 2 ppm (12 mg/m^3)
- STEL 3 ppm (18 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 200 mg/m^3

CANDELLILA WAX (9.1)

Occurrence
- Sizing agent

Description
- Yellowish-brown, opaque to translucent solid, insoluble in water, combustible and nontoxic

Specific Gravity: 0.983
Melting Point: 67°C-68°C

CARBON BLACK (9.1)

Occurrence
- Dye and coloring agent in paper and carbon paper

Synonym(s)
- Carbon
- Acetylene Black
- Channel Black
- C.I. 77266
- C.I. Pigment Black 6 and 7
- Dixie
- Lamp Black
- High-abrasion furnace black

Description
- Fine, black, odorless powder, insoluble in water, suspected carcinogen with impurities

Boiling Point: 4200°C

Specific Gravity: 1.8-2.1

Permissible Exposure Limits in Air
- 3.5 mg/m^3 TWA OSHA
- STEL 7 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- FF52500000

Route of Entry into Body
- Inhalation
- Skin or eye contact
- Ingestion

Symptoms
- Conjunctivitis
- Cornea hypoplasia
- Eczema
- Bronchitis
- Skin cancer
- Skin irritation
- Pulmonary degeneration
- Respiratory distress

Target Organs
- Skin
- Paranasal sinus
- Lungs
- Eyes
- Heart
- Respiratory system
- Mucous tissue
- Blood

Protective Equipment Requirements
- Wear impervious clothing and boots
- Wear gloves
- Prevent repeated or prolonged skin contact
- Place contaminated clothing in closed container til laundered or discarded
- Wear goggles - splash proof/dust proof

Wear Eye Protection to Prevent
- Any possibility of eye contact (faceshield or vented goggles)

Work Clothing Should Be Changed
- Daily after work shift if contaminated

Remove Clothing
- Promptly if it is non-impervious and contaminated (shower after each shift prior to leaving premises)

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 18 mg/m^3
  - Dust respirator, with dust mask, single use type permitted
- 35 mg/m^3
  - Dust and mist respirator except single use, except quarter mask
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with half mask
  - Self-contained breathing apparatus
- 175 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Powered air-purifying respirator with high-efficiency filter
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode
  - Type C supplied-air respirator with full facepiece operated in pressure demand or positive-pressure mode
  - Auxiliary self contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Immediately when skin becomes contaminated (shower at end of each shift) (wash hands, arms, face, neck at each departure from work area)

First Aid

- If carbon black gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifing the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin immediately flush with soap or mild detergent and water. If it soaks through clothing immediately remove clothing and flush skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history with emphasis on cardio-vascular disease
- Physician to evaluate risk of steroids, genetic background, pregnancy or cigarette smoking
- Increased risk exposure
- EKG recommended if employee to wear full-face respirator
- Pre-placement and annual exams

- Medical warnings for refusal of medical exam
- Sputum cyctology when benzene present
- Blood chemistry
- CBC
- 14 by 17 Chest P.A. X-ray
- Urinalysis
- Vision test
- Electrocardiogram
- Pulmonary functions
- Blood cell morphology (differential)
- Reticulocyte count
- SGOT
- SGPT
- LDH
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Dry sweeping or dry mopping of area prohibited (carcinogenic)
- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Immediately douse with water and cover with wet sand or dirt

Personal Danger Situation Protection

- Avoid breathing dust
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Collect solid substance in most safe way for reclamation
- Place in sealed containers in secured sanitary landfill
- Absorb with vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls of overtopping, flooding or other spurious discharge required by EPA (RCRA).

CARBON DIOXIDE (4.1)

Occurrence

- Reacted with water to form carbonic acid. Used in sulfite process to recover sodium base liquor

Synonym(s)

- Carbonic acid gas
- Dry ice

Description

- Colorless, odorless gas

Boiling Point: -78.6°C (sublimes)

Solubility in Water, g/100 g water at 20°C: 0.14%
Melting Point: -56.6°C
Specific Gravity: 1.53
Permissible Exposure Limits in Air
- 5,000 ppm ACGIH (9,000 mg/m^3)
- STEL 15,000 ppm ACGIH (18,000 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 50,000 ppm

CARBON MONOXIDE

(2.2)
(3.2)
(4.2)
(5.2)
(6.2)

Occurrence
- General papermill emission (liquor recovery units and furnaces)

Synonym(s)
- Monoxide
- Carbonic oxide
- Exhaust gas
- Flue gas

Description
- Colorless, odorless gas, mutagen and teratogen suspect

Boiling Point: -191.6°C
Solubility in Water, g/100 g Water at 20°C: 0.004%
Melting Point: -198.8°C
Specific Gravity: 0.96716
Permissible Exposure Limits in air
- 50 ppm ACGIH (55 mg/m^3)
- 35 ppm NIOSH, 200 ppm Ceiling
- 9 ppm 8-hour TWA EPA, 35 ppm 1-hour TWA
- STEL 400 ppm ACGIH (440 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 1500 ppm (1718 mg/m^3)

Registry Toxic Chemicals Number
- FG3500000

Route of Entry into Body
- Inhalation

Symptoms
- Headache
- Nausea
- Weakness
- Dizziness
- Confusion
- Hallucinations
- Cyanosis
- Frostbite
- Unconsciousness
- Gasping
- Ataxia

Target Organs
- Peripheral nervous system
- Lungs

- Blood
- Central nervous system

Protective Equipment Requirements
- Wear faceshield (8 inch minimum)
- Wear goggles - splash proof/dust proof

Respirator Selection (Upper Limit Devices Permitted)
- 500 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 1500 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
  - Type C supplied-air respirator operated in pressure demand, positive-pressure mode or continuous flow mode
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

First Aid
- If a person breathes in large amounts of carbon monoxide, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Emphasis on cardio-vascular disease
- Pulmonary functions
- Emphasis on blood disease
- Emphasis on central nervous system
- EKG recommended if employee to wear full-face respirator
- Mutagenic suspect agent -- medical warning
- Teratogenic suspect agent -- medical warning
- CBC
- Hematology
- Blood cell morphology (differential)
- Pre-placement and annual exams
- Carboxyhemoglobin determination when exposed
- 14 by 17 chest P.A. X-ray

Leaks and Spill Procedures
- Restrict persons without protective equipment
- Ventilate to disperse gasses
- Stop flow of gas

Personal Danger Situation Protection
- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Wear boots, protective gloves and gas-tight goggles

Waste Disposal Method
- Incineration

CARBON TETRACHLORIDE (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Tetrachloromethane
- ENT 4,705
- Halon 104
- Necatorine
- Methane tetrachloride
- Perchloromethane

Description
- Colorless liquid, ether-like odor, noncombustible, carcinogen suspect

Boiling Point: 76.74°C

Solubility in Water, g/100 g water at 20°C: 0.08%

Melting Point: -22.7°C

Specific Gravity: 1.585 (25°C/4°C)

Permissible Exposure Limits in Air
- 10 ppm (65 mg/m^3) 8-hour TWA, 25 ppm ceiling
- 5 ppm (30 mg/m^3) ACGIH (skin)
- 2 ppm 1-hour ceiling NIOSH
- STEL 20 ppm (125 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 300 ppm

Registry Toxic Chemicals Number
- FG4900000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Eye irritation
- Skin irritation
- Headache
- Kidney degeneration
- Vomiting
- Central nervous system depression
- Dizziness
- Unconsciousness
- Hepatic degeneration
- Drowsiness
- Jaundice
- Dark urine

Target Organs
- Lungs
- Eyes
- Skin

- Central nervous system
- Kidneys
- Liver

Protective Equipment Requirements

- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch miminum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent

- Any possibility of eye contact

Remove Clothing

- Promptly if it is non-impervious and contaminated

The Following Equipment Should be Available

- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 100 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 300 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes contaminated

First Aid

- If carbon tetrachloride gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac

as directed on package. This non-prescription drug should be kept with emergency medical supplies in the work place and is available at most drug counters. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- Emphasis on renal and liver functions
- CBC
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- Electro-cardiogram
- Pulmonary functions
- With emphasis on cardiovascular disease
- Morphological blood slides
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Thermal decomposition to phosgene can occur
- Apply water spray to knockdown vapors
- Vapor knockdown water may be corrosive or toxic and should be contained
- Keep material out of water sources and sewers

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

CARBOXYMETHYLCELLULOSE (9.1)

Occurrence

- Paper and paperboard coating and filler
- Sizing and water-retention agent

Description
- Semisynthetic, water-soluble polymer, colorless, odorless, powder or granules, nontoxic

Specific Gravity: 1.59

CARNAUBA WAX (9.1)

Occurrence
- Sizing

Synonym(s)
- Brazil wax

Description
- Hard solid, yellow to greenish brown lumps, slight odor, insoluble in water, combustible, nontoxic

CAROB-SEED GUM (9.1)

Occurrence
- Binding agent
- Wet-strength/dry-strength agent
- Formation aid

Synonym(s)
- Locust bean gum

Description
- Polysaccharide plant mucilage, swells in cold water, becomes viscous when heated, combustible and nontoxic.

CASEIN (9.1)

Occurrence
- Binding agent and adhesive
- Sizing agent

Description
- White, tasteless, odorless amorphous solid, deteriorates when damp, insoluble in water, hygroscopic

Specific Gravity: 1.25-1.31

CASTOR OIL (9.1)

Occurrence
- Coating, lubricant

Synonym(s)
- Ricinus oil

Description
- Pale-yellowish or almost colorless, transparent viscous liquid, mild odor, combustible, low toxicity

Specific Gravity: 0.945-0.956 (25°C/25°C)

CATIONIC DIALDEHYDE STARCH (9.1)

Occurrence
- Wet-strength agent

Description
- Cationic dispersion (15% solids) added to pulp

CATIONIC MONOGALACTAN (9.1)

Occurrence
- Drainage aid
- Dispersion agent

CETYL ALCOHOL (9.1)

Occurrence
- Emulsifier and defoaming agent

Synonym(s)
- Alcohol C-16
- Cetylic alcohol
- 1-Hexadecanol
- Normal primary hexadecyl alcohol
- Palmityl alcohol

Description
- White, waxy solid, faint odor, insoluble in water, combustible, low toxicity

Specific Gravity: 0.8176 (49.5°C)
Melting Point: 49.3°C
Boiling Point: 344°C

CHITOSAN (9.1)

Occurrence
- Wet-strength agent

Description
- Deacetylated polyamide of chitin, a polysaccharide derived from crab and shrimp shell residues

CHLORINE (2.12)

(3.1)

Occurrence (4.1)
- Chemical bleaching (5.1)
- Trace element in power boilers (oil-fired) (9.1)
- Germicide (-.4)

Description
- Amber liquid or greenish yellow gas with a characteristic irritating odor

Boiling Point: -33.8°C

Solubility in Water, g/100 g Water at 20°C: 0.7%
Melting Point: -100.5°C
Permissible Exposure Limits in Air
- 1 ppm ACGIH (3 mg/m^3)
- STEL 3 ppm ACGIH (9 mg/m^3)
- 0.5 ppm NIOSH (15 minute sampling)

Immediately Dangerous to Life or Health Concentration
- 25 ppm (75 mg/m^3)

Registry Toxic Chemicals Number
- F02100000

Route of Entry into Body
- Inhalation
- Skin or eye contact

Symptoms
- Eye irritation
- Pulmonary irritation
- Lacrimation
- Nose/nasal irritation
- Sneezing
- Cough
- Cardiac pain
- Pneumonia
- Skin burn
- Vesiculation
- Dental erosion
- Substernal pain
- Unconscious
- Tracheobronchitis
- Pulmonary edema
- Pneumonitis

Target Organs
- Lungs
- Respiratory system

Protective Equipment Requirements
- Prevent any possiblity of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform person handling contaminated clothing of hazardous properties of substance

Clothing Should Be Changed Daily
- If there is possibility that clothing may be contaminated

Remove Clothing
- Promptly if it is non-impervious and contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

Respirator Selection (Upper Limit Devices Permitted)
- 25 ppm
  - Chemical cartridge respirator with organic vapor cartridge, with full facepiece (avoid oxidizable filter materials)

  - Gas mask with chin-style or front- or back-mounted with organic vapor canister (avoid oxidizable filter materials)
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
  - Supplied-air suits to prevent skin contact
  - Auxiliary self-contained breathing apparatus
- Escape
  - Gas mask with full facepiece
  - Self-contained breathing apparatus with full facepiece
- Firefighting
  - Self-contained breathing apparatus with full facepiece

Employee Should Wash

- Immediately when skin becomes contaminated

First Aid

- If chlorine gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemial gets on skin, immediately flush with water. If it penetrates clothing immediately remove clothing and flush skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiraton. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance

- General medical history
- Industrial exposure history
- Physician examination
- Respiratory history
- Vision test
- Pulmonary functions
- 14 by 17 chest P.A. X-ray
  - With emphasis on cardio-vascular disease
- Eye disease check
- Gum and teeth
- Skin exam
- Periodic exam following exposure
- Increased risks exposure
- Pre-placement and annual exams
- X-ray, repeat when pulmonary results or other respiratory test indicated
- Olfactory ability

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- Apply water spray to knock down vapors
- Vapor knockdown water is corrosive or toxic and should be contained

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind

- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- Wear full protective clothing (fireman's gear inadequate)
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Incineration, preferably after mixing with another combustible fuel; care must be exercised to assure complete combustion to prevent the formation of phosgene; an acid scrubber is necessary to remove halo acids produced.
- Recover and purify by distillation where possible.

CHLORINE DIOXIDE

(2.1)
(3.1)
(4.1)
(5.1)

Occurrence

- Chemical bleaching (generated on-site)

Synonym(s)

- Chlorine oxide
- Chlorine peroxide

Description

- Yellow-green-orange gas or liquid, sharp pungent odor

Boiling Point: 11.1°C

Solubility in Water, g/100 g Water at 20°C: 0.8%

Melting Point: -59.5°C

Permissible Exposure Limits in Air

- 0.1 ppm (0.3 mg/m^3)
- STEL 0.3 ppm ACGIH (0.9 mg/m^3)

Immediately Dangerous to Life or Health Concentration

- 10 ppm

Registry Toxic Chemicals Number

- F03000000

Route of Entry into Body

- Inhalation
- Skin absorption
- Skin or eye contact

Symptoms

- Eye irritation
- Nose/nasal irritation
- Plumonary irritation
- Cough
- Wheezing
- Bronchitis
- Pulmonary edema

Target Organs

- Respiratory system
- Lungs
- Eyes

Protective Equipment Requirements

- Prevent skin contact
- Wear impervious clothing and boots

- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Work Clothing Should Be Changed Daily
- After work shift if contaminated

Remove Clothing
- Immediately if it is contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 5 ppm
  - Chemical cartridge respirator with organic vapor cartridge, with full facepiece (avoid oxidizable filter materials)
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 10 ppm
  - Type C supplied-air respirator operated in pressure demand, positive-pressure or continuous-flow mode, with dust, mist, fumes filter
  - Self-contained breathing apparatus with full facepiece (must not contain oxidizable filter)
- Escape
  - Gas mask with organic vapor cartridge providing protection against compound of concern
  - Chin-style or front- or back-mounted
  - Self-contained breathing apparatus with full facepiece (avoid oxidizable filter materials)
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If chlorine dioxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush with soap or mild detergent and water. If this chemical soaks thru clothing, promptly remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiraton. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- If the chemical has been swallowed and the person is conscious, immediately give him large quantities of water to dilute the chemical. DO NOT attempt to make the exposed person vomit. Get medical attention as soon as possible.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Urinalysis
- Vision test
- Electro-cardiogram
- Pulmonary functions
- Skin exam

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Ventilate to disperse fumes/gasses
- Stop flow of gas
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- If liquid, allow to evaporate

Personal Danger Situation Protection

- Avoid breathing vapors
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus
- If body contact necessary, wear full protective gear

Waste Disposal Method

- Introduce into large volume and solution of reducing agent (bisulfite, ferrous salts or hypochlorite), neutralize and flush to sewer with water.

CHLOROBENZENE (8.2)

Occurrence

- Final effluent (tissue paper deinking process)

Solubility in Water, g/100 g water at 20°C: 0.05

Permissible Concentrations in Water

- 250 micrograms/l (freshwater, acute)
- 160 micrograms/l (saltwater, acute)
- 488 micrograms/l (human)

Permissible Exposure Limits in Air

- 75 ppm (350 mg/m^3)

Immediately Dangerous to Life or Health Concentration

- 2,400 ppm

Registry Toxic Chemicals Number
- CZ0175000

CHLORODEHYDROABIETIC ACID

(2.2)
(3.2)
(4.2)
(5.2)
(8.2)

Occurrence
- Final effluent

CHLORODIFLUOROMETHANE

Occurrence
- NOHS walk-through

Synonym(s)
- Arcton 4
- Algofrene type G
- Difluorochloromethane
- Fluorocarbon 22
- Freon
- Monochlorodifluoromethane
- Freon 22
- Frigen

Description
- Colorless, nearly odorless, nonflammable gas, soluble in water

Boiling Point: -40.8°C
Melting Point: -146.1°C
Specific Gravity: 3.87
Permissible Exposure Limits in Air
- 3500 mg/m^3 ACGIH
- STEL 4375 mg/m^3

2-CHLOROETHYLTRIMETHYL AMMONIUM CHLORIDE

(-.4)

Occurrence
- Plant growth regulator

Synonym(s)
- Chlormequat

CHLOROFORM

(-.24)

Occurrence
- Final effluent
- NOHS walk-through

Synonym(s)
- Trichloromethane
- Methane Trichloride
- Cobehn Spray-Clean Solvent

Description
- Colorless liquid, sweet pleasant odor, noncombustible, carcinogen suspect

Boiling Point: 61.1°C
Solubility in Water g/100 g Water at 20°C: 0.8%
Melting Point: -63.3°C
Specific Gravity: 1.485 (20°C/20°C)

Permissible Exposure Limits in Air

- 25 ppm ACGIH (1976)
- 50 ppm (240 mg/m^3)
- STEL 50 ppm ACGIH (225 mg/m^3)
- 10 ppm TWA ACGIH
- 2 ppm ceiling NIOSH

Permissible Concentration in Water

- Preferrably zero (1.9 micrograms/l ceiling)

Immediately Dangerous to Life or Health Concentration

- 1000 ppm

Registry Toxic Chemicals Number

- FS9100000

Route of Entry into Body

- Inhalation
- Ingestion
- Skin or eye contact

Symptoms

- Dizziness
- Depression
- Headache
- Nausea
- Fatigue
- Anesthesia
- Eye irritation
- Skin irritation
- Hepatic hypertrophy
- Dysarthia
- Pulmonary cancer

Target Organs

- Liver
- Kidneys
- Heart
- Eyes
- Skin

Protective Equipment Requirements

- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Remove Clothing

- Promptly if it is non-impervious and contaminated

Wear Eye Protection to Prevent

- Any possibility of eye contact

The Following Equipment Should Be Available

- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 500 ppm
    - Supplied-air respirator
    - Self-contained breathing apparatus
- 1000 ppm
    - Supplied-air respirator with full facepiece, helmet or hood
    - Self-contained breathing apparatus with full facepiece
- Escape
    - Gas mask with organic vapor canister
    - Self-contained breathing apparatus
- Firefighting
    - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes wet

First Aid

- If chloroform gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately flush skin with water. If irritation persists after washing, get medical attention immediately.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Attention to smoking, alcohol, medication and exposure to carcinogens
- Blood chemistry
    - With emphasis on renal and liver functions
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions
- Vision test
- Urinalysis
    - With emphasis on kidney disease
    - With emphasis on liver disease

- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning
- Thyroid tests
- General cancer exam

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Combustion products include corrosive or toxic vapors
- Thermal decomposition to phosgene can occur

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Incineration, preferrably after mixing with another combustible fuel care must be exercised to assure complete combustion to prevent the formation of phosgene. An aid scrubber is necessary to remove the halo acids produced.
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls of overtopping, flooding or other spurious discharge required by EPA (RCRA).

2-CHLOROPHENOL (4.2)

(8.2)

Occurrence

- Final effluent (papergrade sulfite and deinking operations)

Permissible Concentrations in Water

- 4,380 micrograms/l (freshwater)
- 0.1 micrograms/l (human)

Registry Toxic Chemicals Number

- SK2625000

CHLOROPRENE (9.1)

Occurrence

- Component of neoprene rubber coating

Synonym(s)

- 2-Chloro-1,3-Butadiene
- Chlorobutadiene
- Beta-Chloroprene
- Neoprene

Description

- Colorless liquid with ether-like odor, insoluble in water, combustible, carcinogen suspect

Boiling Point: 59.4°C
Melting Point: -130°C
Specific Gravity: 0.9583 (20°C/20°C)

Permissible Exposure Limits in Air
- 25 ppm (90 mg/m^3) OSHA
- 10 ppm skin (45 mg/m^3) ACGIH
- 1 ppm (3.6 mg/m^3) 15-minute ceiling NIOSH

Immediately Dangerous to Life or Health
- 400 ppm

Registry Toxic Chemicals Number
- EI9625000

Route of Entry Into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Eye Irritation
- Pulmonary irritation
- Nervousness
- Dermatitis
- Alopecia
- Skin cancer
- Pulmonary cancer

Target Organs
- Respiratory system
- Eyes
- Skin
- Lungs

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
- Any possibility of eye contact

Work Clothing Should Be Changed Daily
Advise:
- If it is probable that clothing is contaminated

Removing Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
Advise:
- Quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 400 ppm
  - Supplied-air respirator with full facepiece, helmet or hood

    - Self-contained breathing apparatus with full facepiece
  - Escape
    - Gas mask with organic vapor canister, chin-style or front- or back-mounted
    - Self-contained breathing apparatus
  - Firefighting
    - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes contaminated

First Aid

- If chloroprene gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately wash with soap or mild detergent and water. If it soaks through clothing, immediately remove clothing and flush skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, immediately get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- General cancer exam
- Attention to smoking, alcohol, medication and exposure to carcinogens
- Skin exam
- Pulmonary functions
- Vision test
- Urinalysis
- EKG recommended if employee to wear full-face respirator
- 14 by 17 chest P.A. X-ray
- CBC
- Blood chemistry
- Carcinogen suspect agent -- medical warning
- Doctors, lawyers provide medical warnings to employees in writing

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If liquid, use paper towels to absorb small quantities
- To evaporate, use fume hood

- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Avoid breathing vapors
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus

Waste Disposal Methods
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- Do not dump unneutralized substance in sewer due to explosivity
- For pits, lagoons, pools or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls of overtopping, flooding or other spurious discharge required by EPA (RCRA).

CHROMIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Chromic anhydride
- Chromic trioxide

Description
- Dark red solid, absorbs moisture to become deliquescent, carcinogen suspect

Boiling Point: Decomposes

Solubility in Water, g/100 g water at 20°C: 63%

Melting Point: 196°C

Specific Gravity: 2.67-2.82

Permissible Exposure Limits in Air
- 1 mg/m^3 8-hour TWA
- 0.001 mg/m^3 NIOSH

Immediately Dangerous to Life or Health Concentration
- 30 mg/m^3

Registry Toxic Chemicals Number
- GB6650000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Nose irritation

- eye irritation
- Bronchitis
- Pulmonary irritation
- Hepatic degeneration
- Kidney degeneration
- Leukocytosis
- Conjunctivitis
- Vesiculation of skin
- Dermatitis
- Sensitization
- Pulmonary cancer
- Eosinophilia

Target Organs

- Central nervous system
- Eyes
- Lungs
- Liver
- Blood
- Respiratory system
- Skin

Protective Equipment Requirements

- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent

- Any possibility of eye contact

Remove Clothing

- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available

- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 5 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 30 mg/m^3
  - Powered air purifying respirator with full facepiece, with high efficiency particulate respirator with full facepiece
  - Type C supplied-air respirator with full facepiece, helmet, or hood, operated in continuous flow mode
- Escape
  - High-efficiency particulate respirator
  - Self-contained breathing apparatus

- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated

First Aid
- If chromic acid gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and flush skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Attention to smoking, alcohol, medication and exposure to carcinogens
- Heavy metals blood and urine tests
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions
- General cancer exam
- Skin exam
- Morphological blood slides
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- Keep material out of water sources and sewers
- Neutralize spilled material with crushed limestone, soda ash or lime
- Keep sparks, flames and other ignition sources away

Personal Danger Situation Protection
- If body contact necessary, wear full protection gear
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors

- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Approach fire with caution

Waste Disposal Methods
- Place in sealed container in secured sanitary landfill
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls of overtopping, flooding or other spurious discharge required by EPA (RCRA).

CHROMIC OXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Chromium oxide
- Chromia
- Chromium sesquioxide
- Green cinnabar

Description
- Bright green, extremely hard crystals, insoluble in water. Toxic by ingestion and inhalation, known carcinogen.

Specific Gravity: 5.04
Melting Point: 2435°C
Boiling Point: 4000°C
Permissible Exposure Limits in Air
- 0.5 mg/m^3

CHROMIC POTASSIUM SULFATE

Occurrence
- NOHS walk-through

Synonym(s)
- PEL
- Potassium chrome alum
- Potassium chromium sulfate
- Chromium potassium alum

Description
- Red-violet solid, odorless, carcinogen suspect

Boiling Point: Decomposes
Solubility in Water, g/100 g water at 20°C: 19.6%
Melting Point: 89°C
Permissible Exposure Limits in Air
- 1 mg/m^3 8-hour TWA

CHROMIC SULFATE

(2.1)
(3.1)
(4.1)
(5.1)

Occurrence
- Chlorine dioxide preparation

Synonym(s)
- Chromium sulfate

Description
- Violet or red powder, insoluble in water. Pentadecahydrate occurs as dark green amorphous scales, soluble in water. Octadecahydrate occurs as violet cubes, soluble in water

Specific Gravity: 3.012
1.867 (pentadecahydrate)
1.70 (octadecahydrate)

CHROMIUM

(-.2)

Occurrence
- Final effluent

Description
- Insoluble in water, known carcinogen. Hexavalent chromium toxic and corrosive to tissue.

Permissible Exposure Limits in Air
- 1.0 mg/m^3
- 0.5 mg/m^3 ACGIH

Immediately Dangerous to Life or Health Concentration
- 500 mg/m^3

Permissible Concentrations in Water
- 0.29 micrograms/l (freshwater, 24-hour average)
- 21.0 micrograms/l (freshwater, ceiling)
- 18 micrograms/l (saltwater, 24-hour average)
- 1,260 micrograms/l (saltwater, ceiling)
- 50 micrograms/l (human)

Registry Toxic Chemicals Number
- GB4200000

CHRYSENE

(10.2)

Occurrence
- Component of asphalt fume

Synonym(s)
- 1,2-Benzphenanthrene
- Polynuclear aromatic hydrocarbon

Description
- Crystalline form, carcinogen

CITRIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- 2-hydroxy-1,2,3-propanetricarboxylic acid

Description
- Colorless, translucent crystals or powder, odorless, strongly acid taste, soluble in water, combustible and nontoxic

Specific Gravity: 1.542
Melting Point: 153°C (anhydrous form)

COBALT 2-ETHYLHEXOATE

Occurrence
- NOHS walk-through

Synonym(s)
- Cobalt octoate

Description
- Blue liquid

Specific Gravity: 1.013 (25°C)

COBALTIC OXIDE (9.1)

Occurrence
- Pigments

Synonym(s)
- Cobalt oxide
- Cobalt black

Description
- Steel-gray or black powder, insoluble in water

Specific Gravity: 4.81-5.60
Melting Point: 895°C (Decomposes)

COBALTOUS LINOLEATE

Occurrence
- NOHS walk-through

Synonym(s)
- Cobalt linoleate

Description
- Brown, amorphous powder, combustible, insoluble in water

COPPER (2.2)

(3.2)

Occurrence (4.2)
- NOHS walk-through (pigment) (5.2)
- Final effluent (6.2)

Synonym(s) (7.2)
- Copper (8.2)
- Copper oxide (9.12)
- C.I. 77400 (10.2)

- C.I. pigment metal 2
- 1721 gold
- Bronze powder
- Cuperous oxide

Description

- Finely divided particulates, insoluble in water

Boiling Point: 1235°C

Permissible Exposure Limits in Air

- 0.1 mg/m^3 (0.04 ppm)
- 0.2 mg/m^3 ACGIH

Permissible Concentrations in Water

- 5.6 micrograms/l (freshwater, 24-hour average)
- 4.0 micrograms/l (saltwater, 24-hour average)
- 1,000 micrograms/l (human)

Registry Toxic Chemicals Number

- GL7525000

COPPER SULFATE (1.1)

Occurrence

- Preservation of pulpwood

Synonym(s)

- Cupric sulfate
- Blue vitrol
- Blue stone
- Blue copperas

Description

- Blue crystals or blue crystalline granules or powder, white when dehydrated. Soluble in water, toxic by ingestion, strong tissue irritant.

Specific Gravity: 2.284

Registry Toxic Chemicals Number

- GL8900000

CRESOL

Occurrence

- NOHS walk-through

Synonym(s)

- Cresylic acid
- Hydroxytoluol
- 2,3-Methyl phenol

Description

- Colorless solid or liquid, sweet tarry odor, carcinogen suspect

Boiling Point: 191°C-203°C

Solubility in Water, g/100 g Water at 20°C: 1.9%-2.5%

Melting Point: 11°C-35°C

Specific Gravity: 1.030-1.047

Permissible Exposure Limits in Air

- 5 ppm (22 mg/m^3)

Registry Toxic Chemicals Number
- G05950000

CRESOL PURPLE (9.1)

Occurrence
- Acid-base indicator

Synonym(s)
- meta-Cresolsulfonphthalein

Description
- Shows color change from red to yellow over pH range 1.2 to 2.8 and from yellow to purple over pH range 7.4 to 9.0.

CRESOL RED (9.1)

Occurrence
- Acid-base indicator

Synonym(s)
- ortho-Cresolsulfonphthalein

Description
- Substance changes from yellow to red between pH range 7.0 and 8.8.

CROTONIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- 2-Butenoic acid
- Beta-methacrylic acid

Description
- White, crystalline solid, soluble in water, combustible, strong tissue irritant.

Specific Gravity: 0.9730
Melting Point: 72°C
Boiling Point: 185°C

CUMENE HYDROPEROXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Alpha, alpha-dimethylbenzyl hydroperoxide

Description
- Colorless to pale yellow liquid, slightly soluble in water, combustible. Toxic by inhalation and skin absorption.

CUPROUS CHLORIDE

Occurrence
- NOHS walk-through

Description
- White cubical crystals, becomes greenish on exposure to air, brown on exposure to light, slightly soluble in water.

Specific Gravity: 4.14
Melting Point: 430°C
Boiling Point: 1490°C

CYANIDE (5.2)

(7.2)

Occurrence (8.2)
- Final effluent (9.2)

Description (10.2)
- Soluble in water, highly toxic by ingestion, inhalation, skin absorption (11.2)

Permissible Exposure Limits in Air
- 5 mg/m^3 (10-minute ceiling) NIOSH

Immediately Dangerous to Life or Health Concentration
- 50 mg/m^3

Permissible Concentrations in Water
- 3.5 micrograms/l (freshwater, 24-hour average)
- 52 micrograms/l (freshwater, ceiling)
- 30 micrograms/l (saltwater, ceiling)
- 2.0 micrograms/l (saltwater, 24-hour average)
- 200 micrograms/l (human)

Registry Toxic Chemicals Number
- TS8750000 (potassium cyanide)
- VZ7525000 (sodium cyanide)

CYCLOHEXANOL

Occurrence
- NOHS walk-through

Synonym(s)
- Hexaline hydraline hydroxycyclohexane
- Anol hexhydrophenol
- Cyclohexyl alcohol
- Adronal
- Hexalin
- Naxol
- Hydrophenol
- Hydralin

Description
- Colorless, viscous liquid or sticky solid with a faint camphor odor, combustible, moderately toxic, narcotic in high concentrations

Boiling Point: 160.9°C
Solubility in Water, g/100 g Water at 20°C: 3.6%

Melting Point: 23°C
Specific Gravity: 0.937 (37°C/4°C)
Permissible Exposure Limits in Air
- 50 ppm (200 mg/m^3)

CYCLOHEXYLAMINE

Occurrence
- NOHS walk-through

Synonym(s)
- Cyclohexanamine
- Aminocyclohexane
- Aminohexahydrobenzene
- CHA
- Hexahydroaniline
- Hexahydrobenzenamine

Description
- Colorless liquid, characteristic fishy odor, soluble in water, mutagen and teratogen suspect

Boiling Point: 134.5°C
Melting Point: -18°C
Specific Gravity: 0.865
Permissible Exposure Limits in Air
- 10 ppm (40 mg/m^3)ACGIH (skin)

CYMENE (ORTHO-, META-, and PARAISOMERS) (4.2)

Occurrence
- NOHS walk-through
- Sulfite pulping effluent

Synonym(s)
- Cymol
- Isopropyltoluene
- Methylpropylbenzene

Description
- Colorless, transparent liquid, aromatic odor, insoluble in water combustible; moderately toxic by ingestion

Specific Gravity: (ortho) 0.8748
(meta) 0.862
(para) 0.8551

Boiling Point: (ortho) 177°C
(meta) 175.6°C
(para) 176.5°C

DEACETYLATED KARAYA GUM (9.1)

Occurrence
- Formation aid

Description
- Carbohydrate polymer with various chemical properties. Forms translucent, colloidal gel in water.

DEHYDROABIETIC ACID (-.2)

Occurrence
- Final effluent

Registry Toxic Chemicals Number
- TP8710000

O-DIANISIDINE (9.1)

Occurrence
- Azo dye intermediate

Synonym(s)
- Di-para-aminodi-meta-methoxydi-phenyl
- 3,3'-Dimethyoxybenzidine

Description
- Colorless crystals, insoluble in water, combustible, moderately toxic

Melting Point: 137.5°C

DIBROMOCHLOROMETHANE (10.2)

Occurrence
- Final effluent (builders' paper and roofing felt processes)

Permissible Concentration in Water
- 0.10 micrograms/l (drinking)

Registry Toxic Chemicals Number
- PA6360000

DIPHENYLMETHANE (9.1)

Occurrence
- Dyes

Synonym(s)
- Benzylbenzene

Description
- Long, colorless needless, combustible, moderately toxic by ingestion

Specific Gravity: 1.0056
Melting Point: 26.5°C
Boiling Point: 264.7°C

2,6-DIBROMOPHENOL (2.2)

(3.2)
Occurrence (4.2)
- Chlorination and extraction stage effluent in chemical bleaching (5.2)

DIBUTYL PHTHALATE

(-.2)
(9.1)

Occurrence
- Paper coating
- Final effluent

Synonym(s)
- Dibutyl ester o-benzenedicarboxylic acid
- Celluflex DBP
- DBP
- Dibutyl 1,2-benzenedicarboxylate
- Dibutyl ester phthalic acid
- Di-n-butyl phthalate
- PX 104
- Polycizer DBP

Description
- Colorless, odorless liquid, teratogen suspect and mutagen suspect

Boiling Point: 340°C

Solubility in Water, g/100 g water at 20°C: less than 0.03 g

Melting Point: -35°C

Specific Gravity: 1.0484 (20°C/20°C)

Permissible Exposure Limits in Air
- ACGIH 5 mg/m^3
- STEL 20 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- TI0875000

DIBUTYLTIN DIACETATE

Occurrence
- NOHS walk-through

Synonym(s)
- Diacetoxybutyltin

Description
- Colorless liquid with a weak vinegar odor, combustible, insoluble in water, carcinogen suspect

Boiling Point: 130°C (2 atm)

Melting Point: 10°C

Permissible Exposure Limits in Air
- 0.007 ppm (0.1 mg/m^3)
- 0.1 mg/m^3 NIOSH 10-hour TWA

Registry Toxic Chemicals Number
- WH6880000

O-DICHLOROBENZENE

Occurrence
- NOHS walk-through

Synonym(s)
- 1,2-dichlorobenzene
- o-Dichlorobenzol

- DCB
- Dowtherm E
- Dilantin DB
- ODB
- ODCB

Description
- Colorless to pale yellow liquid with a pleasant, aromatic odor, combustible, carcinogen suspect

Boiling Point: 172°C-179°C
Solubility in Water, g/100 g water at 20°C: 0.015%
Melting Point: -17.5°C
Specific Gravity: 1.284
Permissible Exposure Limits in Air
- 50 ppm (300 mg/m^3) ceiling

DICHLOROBROMOMETHANE (2.2)

(3.2)
Occurrence (4.2)
- Final effluent (7.2)

Registry Toxic Chemicals Number (10.2)
- PA5310000

DICHLOROCATECHOL (2.2)

(3.2)
Occurrence (4.2)
- Chlorination and extraction stage effluent in chemical bleaching (5.2)

DICHLORODEHYDROABIETIC ACID (2.2)

(3.2)
Occurrence (4.2)
- Final effluent (5.2)

(8.2)
(9.2)

DICHLORODIFLUOROMETHANE (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Refrigerant 12
- Freon 12
- Propellant 12
- Halon 122
- UCON
- Isotron 12
- Ledon 12
- FC 12

Description
- Colorless gas with a characteristic ether-like odor at 20% by volume, noncombustible

Boiling Point: -29.8°C
Solubility in Water, g/100 g water at 20°C: 0.008%
Melting Point: -157.7°C
Specific Gravity: 1.1834

Permissible Exposure Limits in Air
- 1000 ppm (4950 mg/m^3)
- STEL 1250 ppm (6200 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 50,000 ppm

Registry Toxic Chemicals Number
- PA8200000

Route of Entry Into Body
- Inhalation
- Skin or eye contact

Symptoms
- Dizziness
- Tremors
- Unconsciousness
- Cardiac arrhythmia
- Central nervous system depression
- Liver damage
- Bone marrow depression
- Anesthesia
- Retarded heartbeat
- Ataxia
- Salivation
- Lacrimation
- Pulmonary irritation
- Pneumonia
- Frostbite
- Vertigo
- Skin irritation
- Confusion
- Eye(s) irritation

Target Organs
- Cardiovascular system
- Central nervous system
- Liver
- Bone marrow
- Heart
- Lungs
- Eyes
- Skin

Protective Equipment Requirements
- Prevent reasonable probability of skin contact
- Wear impervious clothing
- Wear gloves
- Wear faceshield (8 inch minimum)
- Wear goggles - splash proof/dust proof

- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent

- Reasonable probability of eye contact

Work Clothing Should Be Changed Daily

- If there is any possibility that clothing may be contaminated

Remove Clothing

- Immediately if it becomes wet

Respirator Selection (Upper Limit Devices Permitted)

- 10,000 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 50,000 ppm
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
  - Type C supplied-air respirator with full facepiece operated in pressure demand or positive-pressure mode, or with full facepiece, helmet, or hood operated in continuous flow mode
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- If skin becomes wet or frozen

First Aid

- If dichlorodifluoromethane gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately wash contaminated skin with soap or mild detergent and water. If it soaks through clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance

- General medical history
- Industrial exposure history
- Cardiovascular disease
- Pulmonary functions
- Respiratory history
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Physician examination
- Periodic exam following exposure

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Stop flow of gas

Personal Danger Situation Protection
- Avoid breathing vapors
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment

Waste Disposal Methods
- Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced.

1,1-DICHLOROETHANE (4.2)

Occurrence
- Final effluent (papergrade sulfite)

Description
- Sparingly soluble in water, combustible

Permissible Exposure Limits in Air
- 100 ppm (400 mg/m^3)
- 200 ppm (800 mg/m^3) TWA ACGIH
- STEL 250 ppm (1,010 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 4,000 ppm

Registry Toxic Chemicals Number
- KI0175000

1,2-DICHLOROETHANE (8.2)
(9.2)

Occurrence
- Final effluent (deinking and non-integrated fine paper operations)

Registry Toxic Chemicals Number
- KI0525000

DICHLOROGUAIACOL (2.2)
(3.2)

Occurrence (4.2)
- Chlorination and extraction stage effluent in chemical bleaching (5.2)

2,4-DICHLOROPHENOL (2.2)
(3.2)

Occurrence (4.2)
- Final effluent (5.2)
- Effluent from chlorination and extraction stages in chemical bleaching (8.2)

Boiling Point: 210°C
Melting Point: 45°C
Specific Gravity: 1.383 at 60°C/20°C
Solubility in Water: 4,500 mg/l at 25°C; 4,600 mg/l at 20°C
Registry Toxic Chemicals Number

- SK8575000

DICHLOROTETRAFLUOROETHANE

Occurrence

- NOHS walk-through

Synonym(s)

- 1,2-Dichlorotetrafluoroethane
- Freon 114
- Refrigerant 114
- Halon 242
- Fluorane 114

Permissible Exposure Limits in Air

- 1000 ppm (7000 mg/m^3)
- STEL 1250 ppm (8750 mg/m)3 ACGIH

Description

- Colorless liquid or gas with a very slight, ethereal odor, nonflammable

Boiling Point: 3.55°C
Solubility in Water, g/100 g water at 20°C: 0.01%
Melting Point: -94°C
Specific Gravity: 1.5312

DICYANODIAMIDE (9.1)

Occurrence

- Retention aid

Synonym(s)

- Cyanoguanidine

Description

- Pure white crystals, partially soluble in hot water, nonflammable

Specific Gravity: 1.400 (25°C)
Melting Point: 207°C-209°C

DI-2-DIBUTYLTIN ETHYLHEXOATE

Occurrence

- NOHS walk-through

DIETHANOLAMINE

Occurrence

- NOHS walk-through

Synonym(s)
- 2,2-Iminodiethanol
- Bis(2-hydroxyethyl)amine
- DEA
- 2,2-dihydroxydiethylamine
- Diethylolamine
- Di(2-hydroxyethyl)amine
- Diolamine

Description
- Faintly colored, viscous liquid, mild ammoniacal odor, combustible, soluble in water, carcinogen suspect

Boiling Point: 269°C
Melting Point: 28.0°C
Specific Gravity: 1.092 (30°C/20°C)

Permissible Exposure Limits in Air
- 3 ppm ACGIH

Registry Toxic Chemicals Number
- KL2975000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Cornea damage
- Skin irritation
- Dermatitis
- Erythema
- Pulmonary irritation
- Cough
- Respiratory distress
- Dyspnea
- Central nervous system depression
- Liver damage
- Kidney damage
- Mucous membrane irritation
- Gasping
- Keratitis

Target Organs
- Eyes
- Skin
- Lungs
- Mucous tissue
- Respiratory system
- Kidneys
- Liver

Protective Equipment Requirements
Advise:
- Prevent reasonable possibility of skin contact
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof

- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent

Advise:

- Reasonable possibility of eye contact (faceshield or vented goggles)

Work Clothing Should Be Changed Daily

Advise:

- If it is probable that clothing is contaminated

Remove Clothing

Advise:

- Promptly if it is non-impervious and immediately if it is non-impervious and wet

The Following Equipment Should Be Available

Advise:

- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)

- In general
  - Chemical cartridge with organic vapor cartridge
  - Self-contained breathing apparatus with full facepiece, helmet, or hood
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:

- Promptly when skin becomes contaminated

First Aid

- If diethanolamine gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

No OSHA/NIOSH data; exam not required, but due to hazardous nature of substance, advise following:

- EKG recommended if employee to wear full-face respirator
- General medical history
- Industrial exposure history
- Pre-placement and annual exams
- Medical warning for refusal of medical exam
- Attention to smoking, alcohol, medication and exposure to carcinogens

- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning
- Skin exam
- With emphasis on renal and liver functions

Leaks and Spill Procedures

No OSHA/NIOSH data, but due to hazardous nature of substance, advise:

- Restrict persons without protective equipment until cleanup complete
- Keep material out of water sources and sewers

Personal Danger Situration Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors or dust
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

DIETHYLAMINOETHANOL (-.4)

Occurrence

- NOHS walk-through

Synonym(s)

- 2-Diethylaminoethyl alcohol
- N,N-Diethylethanolamine
- Diethyl-2-hydroxy-ethyl amine
- 2-Diethylamino ethanol
- Deae

Description

- Colorless liquid with a weak ammonia odor, combustible, miscible in water

Boiling Point: 161°C

Melting Point: -70°C

Specific Gravity: 0.88-0.89

Permissible Exposure Limits in Air

- 10 ppm (50 mg/m^3) (skin)

Immediately Dangerous to Life or Health Concentration

- 500 ppm

Registry Toxic Chemicals Number

- KK5075000

Route of Entry into Body

- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms

- Nausea
- Vomiting

- Eye irritation
- Tracheobronchitis

Target Organs

- Respiratory system
- Eyes
- Skin

Protective Equipment Requirements

- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent

- Any possibility of eye contact

Employee Should Wash

- Promptly when skin becomes contaminated

Remove Clothing

- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available

- Eyewash if liquids containing greater than 5% contaminant are present; quick drench

Respirator Selection (Upper Limit Devices Permitted)

- 500 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid

- If diethylaminoethanol gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If it gets on skin, immediately flush contaminated skin with water. If this chemical soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
- Physician exam
- Respiratory history
- Skin exam
- Eye disease
- Pulmonary functions
- General medical history
- Industrial exposure history
- Vision test
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Urinalysis

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Keep upwind
- If body contact necessary, wear full protective gear
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors or dust
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

DIETHYLAMINOETHYL METHACRYLATE (9.1)

Occurrence
- Retention aid

DIETHYLENE GLYCOL

Occurrence
- NOHS walk-through

Synonym(s)
- Dihidroxydiethyl ether
- Diglycol
- DEG

Description
- Colorless, practically odorless, syrupy liquid, sweetish taste, extremely hygroscopic, soluble in water, combustible, toxic by ingestion

Specific Gravity: 1.1184 (20°C/20°C)
Boiling Point: 245°C

DIETHYLENE GLYCOL MONOBUTYL ETHER

Occurrence
- NOHS walk-through

Synonym(s)
- Butyl "Carbitol"

Description
- Colorless liquid, faint butyl odor, soluble in water, combustible and nontoxic

Specific Gravity: 0.9536 (20°C/20°C)
Boiling Point: 230.6°C

DIETHYLENE GLYCOL MONOETHYL ETHER

Occurrence
- NOHS walk-through

Synonym(s)
- "Carbitol" solvent

Description
- Colorless, hygroscopic, slightly viscous liquid, mild pleasant odor, combustible

Specific Gravity: 1.0273 (20°C/20°C)
Boiling Point: 195°C-202°C

DIETHYLENE TRIAMINE

Occurrence
- Starting material for diethylenetriamine-adipic acid polyamide (retention aid)

Synonym(s)
- Aminoethylethandiamine
- DETA
- Bis(2-aminoethyl)amine

Description
- Yellow liquid, ammoniacal odor

Boiling Point: 207°C
Permissible Exposure Limits in Air
- 1 ppm (4 mg/m^3) ACGIH (skin)

DIETHYL PHTHALATE (2.2) (4.2) (5.2) (7.2) (8.2) (9.2) (10.2)

Occurrence
- NOHS walk-through
- Final effluent

Synonym(s)
- Anozol
- Ethyl phthalate
- Diethyl ester phthalic acid
- Neantine
- Solvanol
- Palatinol A
- Phthalol
- DEP

Description
- Clear, colorless, odorless liquid, insoluble in water, teratogen suspect

Boiling Point: 298°C
Melting Point: -40°C
Specific Gravity: 1.120 (25°C/25°C)
Permissible Concentrations in Water
- 350 mg/l (human)

Permissible Exposure Limits in Air
- 5 mg/m^3 ACGIH 8-hour TWA and OSHA
- STEL 10 mg/m^3

Registry Toxic Chemicals Number
- TI1050000

DIGLYCOL STEARATE (9.1)

Occurrence
- Lubricating agent for paper and cardboard

Synonym(s)
- Diethylene glycol distearate

Description
- White, wax-like solid, faint fatty odor, disperses in hot water, combustible and nontoxic

Specific Gravity: 0.9333 (20°C/4°C)
Melting Point: 54°C-55°C

DIISOPROPYLAMINE

Occurrence
- NOHS walk-through

Synonym(s)
- 2-propanamine

Permissible Exposure Limits in Air
- 5 ppm (20 mg/m^3)
- TLV-5 ppm air

Description
- Colorless liquid with an odor like ammonia, miscible in water below 27°C

Boiling Point: 84.1°C
Melting Point: -96.1°C
Specific Gravity: 0.7178 (20°C/20°C)
Registry Toxic Chemicals Number
- IM4025000

2-DIMETHYLAMINOETHANOL (9.1)

Occurrence
- Curing agent in polyamide and amine resins
- Emulsifier found in paints and coatings

Synonym(s)
- 2-Dimethylethanolamine
- Deanol

Description
- Colorless liquid with amine odor, combustible, miscible in water, moderately toxic

Boiling Point: 134.6°C
Specific Gravity: 0.8879 (20°C/20°C)

DIMETHYLDIALLYL AMMONIA CHLORIDE (9.1)

Occurrence
- Retention aid

DIMETHYL DISULFIDE (2.2)

Occurrence
- Kraft digester, black liquor oxidation, other components of the kraft pulping system

Description
- Eye irritant, may be toxic

Registry Toxic Chemicals Number
- JO1927500

N,N-DIMETHYLDITHIOCARBAMATE (9.1)

Occurrence
- Biocide/slime control agent

O,O-DIMETHYLO-(2,4,5-TRICHLOROPHENYL)PHOSPHOROTHIOATE (-.4)

Occurrence
- Insecticide

Synonym(s)
- Ronnel
- Fenchlorphos
- ET 57
- DOW ET 57
- Ectoral
- ENT 23,284
- Korlan

Description
- White to tan, waxy solid

Boiling Point: Decomposes
Solubility in Water, g/100 g water at 20°C: 0.0044%
Melting Point: 35°C
Specific Gravity: 1.48
Permissible Exposure Limits in Air
- 10 mg/m^3 (0.8 ppm) ACGIH

DIMETHYL SULFATE (9.1)

Occurrence
- Dye component

Synonym(s)
- Methyl sulfate
- Dimethyl monosulfate
- DMS(methyl sulfate)
- Dimethyl sulphate

Description
- Colorless oily liquid, faint onion odor, combustible, carcinogen suspect

Boiling Point: 188°C (Decomposes)
Solubility in Water, g/100 g water at 20°C: 2.8%
Melting Point: -31.6°C
Specific Gravity: 1.3516
Permissible Exposure Limits in Air
- 1 ppm (5 mg/m^3)
- 0.5 mg/m^3 (0.1 ppm) ACGIH

Immediately Dangerous to Life or Health Concentration
- 10 ppm (51.5 mg/m^3)

Registry Toxic Chemicals Number
- WS8225000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin absorption
- Skin or eye contact

Symptoms
- Eye irritation
- Nose irritation

- Dry throat
- Headache
- Giddiness
- Photophobia
- Dyspnea
- Cough
- Angina pectoris
- Cyanosis
- Vomiting
- Icterus

Target Organs
- Eyes
- Respiratory system
- Lungs
- Skin
- Central nervous system
- Kidneys
- Liver

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 10 ppm
    - Supplied-air respirator with full facepiece, helmet, or hood
    - Self-contained breathing apparatus with full facepiece
- Escape
    - Gas mask with organic vapor canister, chin style or front- or back-mounted with full facepiece
    - Self-contained breathing apparatus with full facepiece
- Firefighting
    - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated

First Aid
- If dimethyl sulfate gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- If this chemical gets on skin, immediately flush with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- With emphasis on renal and liver functions
- CBC
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Neutralize spilled material with crushed limestone, soda ash or lime
- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wear self-contained breathing apparatus
- If body contact necessary, wear full protection gear

Waste Disposal Methods
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill

- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

DIMETHYL SULFIDE (2.2)

Occurrence
- Kraft digester and other components of kraft pulping recovery systems

Synonym(s)
- Methyl sulfide

Description
- Colorless, volatile liquid, disagreeable odor, insoluble in water, combustible, moderate eye irritant, when heated effects are similar to those of sulfur dioxide

Specific Gravity: 0.845 (20°C)
Boiling Point: 37.5°C
Registry Toxic Chemicals Number
- PV5075000

DIMETHYL SULFOXIDE (2.2)

Occurrence
- Present in spent kraft pulping liquor (formed by oxidation of dimethyl sulfide)

Synonym(s)
- Methyl sulfoxide
- DMSO

Description
- Colorless hygroscopic liquid, combustible, low toxicity, soluble in water. Potential topical therapeutic uses, readily abosrbed by skin and tissues

Specific Gravity: 1.01 (20°C/20°C)
Melting Point: 18.5°C
Boiling Point: 189°C
Registry Toxic Chemicals Number
- PV6210000

Target Organs
- Skin and eyes
- Central nervous system

Symptoms
- Nausea
- Vomiting
- Chills
- Cramps
- Lethargy
- Mild skin irritation

3,5-DIMETHYLTETRAHYDRO-1,3,5(2H)-THIADIAZINE-2-THIONE

Occurrence
- Biocide

Synonym(s)
- Dazomet

Description
- Crystals, slightly soluble in water. Toxic by ingestion and inhalation

Specific Gravity: 1.30 (20°C)

Melting Point: 100°C

Permissible Exposure Limits in Air
- 10 mg/m^3

DIOXANE

Occurrence
- NOHS walk-through

Synonym(s)
- P-Dioxane
- 1,4-Dioxane
- Diethylene dioxide
- Glycol ethylene ether

Description
- Volatile liquid, variable color, combustible, miscible in water, carcinogen and teratogen suspect

Boiling Point: 101.3°C

Melting Point: 11.6°C

Specific Gravity: 1.0356 (20°C/20°C)

Permissible Exposure Limits in Air
- 100 ppm (360 mg/m^3) OSHA
- 1 ppm (3.6 mg/m^3) NIOSH
- STEL 100 ppm (360 mg/m^3) ACGIH
- 25 ppm (90 mg/m^3) ACGIH

Immediately Dangerous to Life or Health
- 200 ppm (720 mg/m^3)

Registry Toxic Chemicals Number
- JG8225000

Route of Entry into Body
- Skin absorption
- Skin or eye contact
- Ingestion

Symptoms
- Skin irritation
- Eye irritation
- Nose irritation
- Kidney damage
- Liver damage
- Skin cancer
- Hepatic cancer

Target Organs
- Eyes

- Skin
- Kidneys
- Liver
- Reproductive system

Protective Equipment Requirements
  Advise:
  - Prevent any possibility of skin contact
  - Wear impervious clothing
  - Wear gloves
  - Wear faceshield (8 inch minimum)
  - Provide container to store clothing until laundered or discarded
  - Wear goggles - splash proof/dust proof
  - Inform persons handling contaminated clothing of hazardous properties of substance
  - Store used clothing in fireproof container

Wear Eye Protection to Prevent
  Advise:
  - Any possibility of eye contact

Work Clothing Should Be Changed Daily
  Advise:
  - If there is any possibility that clothing may be contaminated (leave clothing and equipment for decontamination and disposal)

Remove Clothing
  Advise:
  - Promptly if it is non-impervious and contaminated and immediately if it is non-impervious and wet
  - Shower after each shift prior to leaving premises

The Following Equipment Should Be Available
  Advise:
  - Eyewash, quick drench
  - No food or drink in work area
  - Water fountain prohibited in work area
  - Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 100 ppm
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode
  - Auxiliary self contained breathing apparatus
- 200 mg/m^3
  - Supplied-air respirator with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:

- Promptly when skin becomes contaminated

First Aid

- If dioxane gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- Attention to smoking, alcohol, medication and exposure to carcinogens
- EKG recommended if employee to wear full facepiece respirator
- Industrial exposure history
- Pre-placement and annual exams
- Periodic exam following exposure
- With emphasis on renal and liver functions
- Skin exam
- Vision test
- Urinalysis
- Pulmonary functions
- Doctors, lawyers provide medical warnings to employees in writing
- General cancer exam
- Carcinogen suspect agent -- medical warning
- Teratogenic suspect agent -- medical warning
- Sperm morphology

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection

- Avoid breathing vapors or dust
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid bodily contact with material

- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Do not dump unneutralized substance in sewer due to explosivity
- Atomize in suitable safe combustion chamber
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

DIPHENYLMETHANE (9.1)

Occurrence

- Dyes

Synonym(s)

- Benzylbenzene

Description

- Long, colorless needles, moderately toxic by ingestion

Specific Gravity: 1.0056
Melting Point: 26.5°C
Boiling Point: 264.7°C

DIPROPYLENE GLYCOL

Occurrence

- NOHS walk-through

Description

- Colorless, slightly viscous liquid, soluble in water, combustible

Specific Gravity: 1.0252 (20°C/20°C)
Boiling Point: 233°C

DIPROPYLENE GLYCOL DIBENZOATE

Occurrence

- NOHS walk-through

Description

- Light-colored liquid, insoluble in water, combustible

Specific Gravity: 1.1271 (20°C/20°C)
Melting Point: 200°C
Boiling Point: 250°C (10 mm)

DIPROPYLENE GLYCOL METHYL ETHER

Occurrence

- NOHS walk-through

Synonym(s)

- Dowanol 50B

- Dowanol DPM
- UCAR solvent 2LM

Permissible Exposure Limits in Air
- 605 mg/m^3 OSHA
- 100 ppm ACGIH
- STEL 150 ppm ACGIH

Description
- Colorless liquid with a slight odor, combustible, miscible in water

Boiling Point: 189°C
Melting Point: -80°C
Specific Gravity: 0.950 (25°C/4°C)
Registry Toxic Chemicals Number
- JM1575000

DISODIUM EDETATE (6.1)

Occurrence
- Sequestering agent in dithionite bleaching (mechanical pulps)

Synonym(s)
- EDTA
- Disodium EDTA
- Disodium ethylenediaminetetraacetate
- Ethylenediaminetetraacetic acid, disodium salt

Physcial Description
- White, crystalline powder, low toxicity, soluble in water

DISODIUM ETHYLENE BISDITHIOCARBAMATE (-.4)

Occurrence
- Plant fungicide

Synonym(s)
- Nabam

Description
- Colorless crystals when pure, easily soluble in water, toxic, irritant to skin and mucous membranes, narcotic in high concentrations.

DISODIUM N-(2-HYDROXYETHYL)-IMINODIACETATE

Occurrence
- NOHS walk-through

2,6-DI-TERT-BUTYL-PARA-CRESOL

Occurrence
- NOHS walk-through

Synonym(s)
- 2,6-tert-butyl-4-methylphenol
- Butylated hydroxytoluene
- BHT

Description
- White crystalline solid, insoluble in water, combustible, toxic

Freezing Point: 70°C
Specific Gravity: 1.048 (20°C/4°C)
Boiling Point: 265°C
Permissible Exposure Limits in Air
- 10 mg/m^3

DI(TERT-NONYL)POLYSULFIDE

Occurrence
- NOHS walk-through

DODECYLPHENOL

Occurrence
- NOHS walk-through

Description
- Straw-colored liquid, phenolic odor, soluble in water, combustible. Toxic by ingestion, inhalation and skin absorption; strong irritant

Specific Gravity: 0.94 (20°C/20°C)
Boiling Point: 154°C-168°C
Permissible Exposure Limits in Air
- 5 ppm

DOLOMITE (4.1)

Occurrence
- Calcium-base sulfite pulping

Description
- Carbonate of calcium and magnesium, may be gray-pink or white with vitreous luster, noncombustible and nontoxic

Specific Gravity: 2.85

EPICHLOROHYDRIN (9.1)

Occurrence
- Component of wet-strength resins and retention aids

Description
- Highly volatile, unstable liquid, slightly soluble in water. Toxic by inhalation, ingestion, skin absorption. carcinogen suspect

Specific Gravity: 1.1761 (20°C/20°C)
Boiling Point: 115.2°C
Permissible Exposure Limits in Air
- 2 ppm

EPOXYSTEARIC ACID

(2.2)
(4.2)
(5.2)
(7.2)

Occurrence
- Final effluent

Registry Toxic Chemicals Number
- RG1300000

ESSENTIAL OILS

Occurrence
- NOHS walk-through

Description
- Pungent taste and odor, usually nearly colorless when fresh, but becoming dark and thick on exposure to air, insoluble in water

Specific Gravity: 0.850-1.100

ESTER GUM

Occurrence
- NOHS walk-through

Description
- Hard, combustible, semisynthetic resin, usually produced by esterification of rosin with glycerol or pentaerythritol

ETHANOL

(4.3)

Occurrence
- NOHS walk-through
- By-product of spent sulfite liquor

Synonym(s)
- Ethyl alcohol
- Cologne spirits
- Grain alcohol
- Spirit of wine
- Ethyl hydrate
- Jaysol S
- Methylcarbinol

Description
- Clear, colorless liquid, soluble in water, carcinogen suspect

Boiling Point: 78.°C

Specific Gravity 1.3651 (15°C)

Permissible Exposure Limits in Air
- 1000 ppm (1900 mg/m^3)

Registry Toxic Chemical Number
- KQ6300000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Eye irritation
- Mucous membrane irritation
- Central nervous system depression
- Intoxication
- Dry throat
- Lacrimation
- Nose/nasal irritation
- Headache
- Somnolence
- Respiratory distress
- Liver damage
- Drowsiness
- Giddiness
- Dizziness
- Anorexia
- Lassitude
- Visual Disturbance
- Tremors

Target Organs
- Central nervous system
- Eyes
- Liver
- Respiratory system

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing Should Be Changed Daily
- Leaving clothing and equipment for decontamination and disposal

Remove Clothing
- Promptly if it is non-impervious and contaminated
- Shower after each shift prior to leaving premises

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- In general
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode

- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated and at end of each work shift

First Aid
- If ethanol gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, flush skin with water. If it penetrates clothing, promptly remove clothing and flush skin with water. Get medical attention immediately.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General medical history
- EKG recommended if employee to wear full facepiece respirator
- Industrial exposure history
- Respiratory history
- Pulmonary functions
- CBC with emphasis on renal and liver functions
- Special attention to history of alcohol use
  - With emphasis on central nervous system
  - With emphasis on liver disease
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent - medical warning

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- To evaporate, use fume hood
- If liquid, use paper towels to absorb small quantities
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- Burn towels in safe place away from combustibles, avoid closed area for disposal due to explosive danger

Personal Danger Situation Protection
- Avoid breathing vapors or dust
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Atomize in suitable safe combustion chamber
- Absorb in vermiculite, dry sand, earth or similar material and then place in sealed containers in secured sanitary landfill
- Do not dump unneutralized substance in sewer due to explosivity
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ETHANOLAMINE (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Ethylolamine
- Monoethanolamine
- Beta aminoethyl alcohol
- Thiofaco M-50
- USAF EK-1597
- 2-Aminoethanol
- 2-Hydroxyethylamine
- MEA

Description
- Colorless liquid, mild ammonia odor, combustible, miscible in water

Boiling Point: 170.5°C
Melting Point: 10.5°C
Specific Gravity: 1.0179 (20°C/20°C)
Permissible Exposure Limits in Air
- 3 ppm (8 mg/m^3)
- 15 mg/m^3 ACGIH
- STEL 6 ppm ACGIH

Registry Toxic Chemicals Number
- KJ5775000

2-ETHOXYBUTANOL

Occurrence
- NOHS walk-through

2-ETHOXYETHANOL (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Cellosolve solvent
- Ethylene glycol monoethyl ether
- Cellosolve
- Dowanol EE

- Poly-solve EE
- Oxitol
- GE mat. D5B16

Description
- Colorless liquid with a sweet odor, combustible, miscible in water, carcinogen and teratogen suspect

Boiling Point: 135.6°C
Melting Point: -70°C
Specific Gravity: 0.9311 (20°C/20°C)

Permissible Exposure Limits in Air
- 200 ppm (740 mg/m^3)
- 50 ppm TWA ACGIH
- STEL 100 ppm (370 mg/m^3) (skin) ACGIH

Immediately Dangerous to Life or Health Concentration
- 6000 ppm (22,000 mg/m^3)

Registry Toxic Chemicals Number
- KK8050000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Respiratory distress
- Liver damage
- Kidney damage
- Testicular atrophy
- Nausea
- Vomiting
- Hematopoietic blood changes
- Leukopenia
- Central nervous system depression
- Reproductive effects
- Lower sperm count

Target Organs
- Respiratory system
- Lungs
- Eyes
- Liver
- Kidneys
- Reproductive system
- Blood

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

Work Clothing Should Be Changed Daily

- If it is probable that clothing is contaminated

Remove Clothing

- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available

- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)

- 2,000 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 6,000 ppm
  - Type C supplied-air respirator, will full facepiece operated in pressure demand, positive-pressure or continuous flow mode
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes contaminated

First Aid

- If 2-ethoxyethanol gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If it gets on skin, immediately flush contaminated skin with water. If this chemical soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Periodic exam followed by exposure
- Skin exam
- Blood chemistry
- Emphasis on renal and liver functions
- CBC
- Morphological blood slides
- With emphasis on chronic respiratory disease

- 14 by 17 chest P.A. X-ray
- EKG recommended if employee to wear full-face respirator
- Physician exam
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning
- Teratogenic suspect agent -- medical warning
- Sperm morphology

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep material out of water sources and sewers
- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus
- If body contact necessary, wear full protection gear

Waste Disposal Methods
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize in suitable safe combustion chamber
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ETHOXYLATED ALCOHOL

Occurrence
- NOHS walk-through

ETHYL ACETATE

Occurrence
- NOHS walk-through

Synonym(s)
- Acetic ester

- Acetic ether
- Ethyl ethanoate
- Acetic acid, ethyl ester

Description
- Colorless liquid, pleasant fruity odor, combustible

Boiling Point: 77°C
Solubility in Water, g/100 g water at 20°C: 8.7%
Melting Point: -83.6°C
Specific Gravity: 0.8945

Permissible Exposure Limits in Air
- 400 ppm (1400 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 10,000 ppm (36,000 mg/m^3)

Registry Toxic Chemicals Number
- AH5425000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Nose irritation
- Eye irriation
- Leukocytosis
- Dermatitis
- Narcosis
- Anemia

Target Organs
- Eyes
- Respiratory system
- Skin

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
- Any possibility of eye contact

Remove Clothing
- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 1,000 ppm
  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
- 5,000 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted

- 10,000 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes contaminated

First Aid

- If ethyl acetate gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed get medical attention immediately. If medical attention is not available, get affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Periodic exam following exposure
- Blood chemistry
- With emphasis on renal and liver functions
- Skin exam
- Vision test
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gases
- Burn towels in safe place away from combustibles. Avoid closed areas for disposal due to explosive danger
- To evaporate, use fume hood
- Keep material out of water sources and sewers

- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors
- Attempt to stop leak if without hazard

Personal Danger Situation Protection
- Keep upwind
- If body contact necessary, wear full protective gear
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize in suitable safe combustion chamber
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ETHYL ACRYLATE (9.1)

Occurrence
- Monomer for acrylic resins

Synonym(s)
- Ethyl propenoate
- 2-propenoic acid, ethyl ester

Description
- Colorless liquid, sharp acrid odor, carcinogen suspect

Boiling Point: 99.4°C

Solubility in Water, g/100 g water at 20°C: 1.5%

Melting Point: -75°C

Specific Gravity: 1.9230 (20°C/20°C)

Permissible Exposure Limits in Air
- 25 ppm (100 mg/m^3)
- 5 ppm ACGIH

Registry Toxic Chemicals Number
- AT0700000

ETHYL BENZENE

(2.2)
(5.2)
(6.2)
(7.2)
(8.2)
(9.2)
(10.2)
(-.4)

Occurrence
- NOHS walk-through
- Final effluent

Synonym(s)
- Phenylethane
- Ethylbenzol

Description
- Colorless liquid, aromatic odor, combustible, carcinogen suspect

Boiling Point: 136.19°C
Solubility in Water, g/100 g Water at 20°C: 0.015%
Melting Point: -95°C
Specific Gravity: 0.867 (20°C)
Permissible Exposure Limits in Air
- 100 ppm (435 mg/m^3)
- STEL 125 ppm (545 mg/m^3) ACGIH

Permissible Concentrations in Water
- 32,000 micrograms/l (freshwater, acute)
- 430 micrograms/l (saltwater, acute)
- 1.4 micrograms/l (human)

Registry Toxic Chemicals Number
- DA0700000

ETHYLCELLULOSE (9.1)

Occurrence
- Hot-melt adhesives and coatings for paper

Description
- White, granular, thermoplastic solid, insoluble in water, nontoxic and noncombustible

Specific Gravity: 1.07-1.18
Softening Point: 100°C-130°C

ETHYL CHLORIDE (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Chloroethane
- Monochloroethane
- Muriatic Ether
- Hydrochloric Ether
- Kelene

Description
- Colorless liquid/gas, pungent ether-like odor, combustible, carcinogen suspect

Boiling Point: 12.5°C
Solubility in Water, g/100 g water at 20°C: 0.6%
Melting Point: -138.8°C
Specific Gravity: 0.9214
Permissible Exposure Limits in Air
- 1000 ppm (2600 mg/m^3) (skin)
- STEL 1250 ppm (3250 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 20,000 ppm (53,000 mg/m^3)

Registry Toxic Chemicals Number
- KH7525000

Route of Entry Into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Incoordination
- Necrosis
- Abdominal cramps
- Cardiac arrhythmia
- Hepatic degeneration
- Kidney degeneration
- Anesthesia

Target Organs
- Liver
- Kidneys
- Respiratory system
- Cardiovascular system

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing
- Wear gloves
- Wear faceshield (8 inch minimum)
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 10,000 ppm
    - Supplied-air respirator
    - Self-contained breathing apparatus
- 20,000 ppm
    - Supplied-air respirator with full facepiece, helmet, or hood
    - Self-contained breathing apparatus with full facepiece
    - Type C supplied-air respirator with full facepiece, helmet or hood and operated in pressure-demand, positive-pressure or continuous flow mode
- Escape
    - Gas mask with organic vapor canister
    - Self-contained breathing apparatus
- Firefighting
    - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Remove Clothing
- Immediately if it becomes wet

First Aid

- If ethyl chloride gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, promptly wash contaminated skin with soap or mild detergent and water. If this chemical soaks clothing, promptly remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, immediately get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Periodic exam following exposure
- With emphasis on renal and liver functions
- With emphasis on cardiovascular disease
- Blood chemistry
- CBC
- Vision test
- EKG recommended if employee to wear full-face respirator
- Urinalysis
- Pulmonary functions
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse gasses
- Stop flow of gas
- If liquid, use paper towels to absorb small quantities
- To evaporate, use fume hood
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Use water spray to knock down vapors

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind

- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus

Waste Disposal Methods
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device

ETHYLENE-BIS-DITHIOCARBAMATE (9.1)

Occurrence
- Biocide/slime control agent

ETHYLENEDIAMINE (9.1)

Occurrence
- Slime control agent

Synonym(s)
- 1,2-Diaminoethane
- 1,2-Ethanediamine

Physical Description
- Colorless liquid/solid, ammonia-like odor, miscible in water

Boiling Point: 116°C
Melting Point: 8.5°C
Specific Gravity: 0.8995
Permissible Exposure Limits in Air
- 10 ppm (25 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 2000 ppm (4900 mg/m^3)

ETHYLENE GLYCOL (9.1)

Occurrence
- Biocide/slime control agent

Synonym(s)
- 1,2-Dihydroxethane
- 1,2-Ethandiol
- Ethylene alcohol
- Lutrol-9
- Monoethylene glycol
- Ethylene dihydrate
- M.E.G.

Description
- Colorless sweet tasting liquid, combustible, miscible in water, carcinogen suspect

Boiling Point: 197.2°C
Melting Point: -13.5°C

Specific Gravity: 1.1144 (20°C)
Permissible Exposure Limits in Air
- 50 ppm (125 mg/m^3) ACGIH

ETHYLENE GLYCOL MONOBUTYL ETHER (9.1)

Occurrence
- Oil-resistant papermaking additive

Synonym(s)
- 2-Butoxyethanol
- Dowanol EB
- Butyl cellcsolve
- Butyl oxitol
- Jeffersol EB
- Ektasolve EB
- Poly-solv EB

Description
- Colorless liquid with a mild odor, combustible, miscible in water, carcinogen suspect

Boiling Point: 171.2°C
Melting Point: -70°C
Specific Gravity: 0.9019
Permissible Exposure Limits in Air
- 50 ppm (240 mg/m^3)
- 25 ppm ACGIH (skin)

ETHYLENE OXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Dimethylene oxide
- 1,2-Epoxyethane
- Oxirane
- ETO
- Anprolene
- EO
- Oxane

Description
- Colorless gas or liquid with an ether odor, miscible in water, carcinogen and teratogen suspect

Boiling Point: 10.73°C
Melting Point: -112.7°C
Specific Gravity: 0.8711 (20°C/20°C)
Permissible Exposure Limits in Air
- 50 ppm (90 mg/m^3)
- 75 ppm 15-min ceiling NIOSH
- 10 ppm (20 mg/m^3) TWA ACGIH

ETHYLENE-VINYL ACETATE COPOLYMER (9.1)

Occurrence
- Pigment filler/coating
- Wet-strength/dry-strength agent

ETHYL ETHER

Occurrence
- NOHS walk-through

Synonym(s)
- Diethyl ether
- Ethyl oxide
- Ether
- Diethyl oxide
- Solvent ether
- Ethoxythane
- Sulfuric ether

Description
- Colorless liquid, characteristic ether odor

Boiling Point: 34.5°C
Solubility in Water, g/100 g water at 20°C: 7.5%
Melting Point: -116.2°C
Specific Gravity: 0.7147
Permissible Exposure Limits in Air
- 400 ppm (1200 mg/m^3)
- STEL 500 ppm (1500 mg/m^3) ACGIH

2-ETHYLHEXYL ACRYLATE (9.1)

Occurrence
- Paper treatment

Description
- Liquid with pleasant odor, insoluble in water, combustible, low toxicity

Specific Gravity: 0.8869
Boiling Point: 214°C-218°C

ETHYL MERCAPTAN (2.2)

Occurrence
- Gaseous emission generated at various stages of the kraft pulping process

Synonym(s)
- Ethanethoil
- Ethyl sulfhydrate

Description
- Strong skunk odor

Permissible Exposure Limits in Air
- 10 ppm (25 mg/m^3)
- 0.5 ppm (1 mg/m^3) TWA ACGIH

- STEL 2 ppm (3 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration

- 2,500 ppm (6,340 mg/m^3)

FATTY ACID ESTERS (-.4)

Occurrence

- Lubricant

Description

- Fatty ester yielded on esterification with an alcohol, usually methanol

FENCHYL ALCOHOL

Occurrence

- NOHS walk-through

Synonym(s)

- Fenchol
- 2-Fenchanol
- 1-Hydroxy-fenchane

Description

- Colorless, oily liquid (D- and L- forms) or solid (DL-form). Highly toxic, cholinesterase inhibitor. Use may be restricted.

Specific Gravity: 0.96
Melting Point: 39°C
Boiling Point: 201°C

FERRIC ALUMINUM SILICATE

Occurrence

- NOHS walk-through

FERRIC CHLORIDE, ANHYDROUS

Occurrence

- NOHS walk-through

Synonym(s)

- Ferric trichloride
- Ferric perchloride
- Iron chloride
- Iron trichloride
- Iron perchloride

Description

- Black-brown solid, soluble in water, noncombustible, toxic by ingestion, strong skin and tissue irritant

Specific Gravity: 2.898 (25°C)
Melting Point: 306°C (Decomposes)
Boiling Point: 319°C

FLUORANTHENE (2.2) (4.2)

Occurrence
- Final effluent (dissolving kraft and sulfite pulp processes)

Permissible Concentrations in Water
- 3,980 micrograms/l (freshwater, acute)
- 40 micrograms/l (saltwater, acute)
- 16 micrograms/l (saltwater, chronic)
- 42 micrograms/l (human)

Registry Toxic Chemicals Number
- LL4025000

FORMALDEHYDE (9.12) (10.1)

Occurrence
- Wet strength additive (resin component)
- Component of building paper

Synonym(s)
- Methylene oxide
- Formalin
- Fyde
- Karsan
- Methyl aldehyde
- G.E. mat D5H1

Description
- Colorless liquid or gas with a pungent irritating odor, miscible in water, carcinogen suspect

Boiling Point: 96.6°C

Melting Point: -92°C

Permissible Exposure Limits in Air
- 5 ppm Ceiling, 10 ppm Peak EPA (30 minutes)
- 3 ppm TWA
- 0.8 ppm (1.2 mg/m^3) NIOSH (30 minutes)
- 2 ppm ACGIH (3 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 100 ppm

Registry Toxic Chemicals Number
- LP8925000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Eye irritation
- Nose irritation
- Bronchospasm
- Lacrimation
- Nose/nasal burn
- Pulmonary irritation
- Dermatitis
- Headache

- Vomiting
- Unconsciousness
- Cough
- Pneumonitis

Target Organs

- Respiratory system
- Lungs
- Eyes
- Skin

Protective Equipment Requirements

Advise:

- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minumum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Remove Clothing

- Promptly if it is non-impervious and contaminated

The Following Equipment Should Be Available

- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 50 ppm
  - Chemical cartridge respirator with organic vapor cartridge (certified for formaldehyde per NIOSH), with full facepiece
  - Gas mask with organic vapor canister (certified for formaldehyde per NIOSH), chin-style or front- or back-mounted
  - Self-contained breathing apparatus with full facepiece
- 100 ppm
  - Supplied-air respirator with full facepiece, operated in pressure demand, positive-pressure or continuous flow mode
- Escape
  - Gas mask with organic vapor canister (certified for formaldehyde per NIOSH), chin-style or front- or back-mounted
  - Self contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Immediately when skin becomes contaminated

First Aid

- If formaldehyde gets into eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- If this chemical gets on skin, flush with water. If it soaks through the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When this chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- Pulmonary functions
- Attention to smoking, alcohol, medication, and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger

Personal Danger Situation Protective

- Avoid breathing vapors
- Wear boots, protective gloves, and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Absorb in vermiculite, dry sand, earth or similar material and then place in sealed containers in secured sanitary landfill
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

FORMIC ACID

Occurrence
- By-product of NSSC pulping

Synonym(s)
- Methanoic acid
- Aminic acid
- Formylic acid
- Hydrogen carboxylic acid

Description
- Colorless liquid, fuming, miscible in water

Boiling Point: 100.8°C

Melting Point: 8.3°C

Specific Gravity 1.2201

Permissible Exposure Limits in Air
- 5 ppm (9 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 100 ppm (188 mg/m^3)

Registry Toxic Chemical Number
- LQ4900000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Eye irritation
- Lacrimation
- Irritation, dry throat
- Cough
- Dyspnea
- Nausea
- Skin burn
- Dermatitis

Target Organs
- Respiratory system
- Lungs
- Skin
- Kidneys
- Liver
- Eyes

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Remove Clothing
- Immediately if it is contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respiratory Selection (Upper Limit Devices Permitted)
- 100 ppm
  - Chemical cartridge respirator with organic vapor canister, with full facepiece, with dust, mist and fume filter
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted with dust, mist and fume filter
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece, helmet or hood
- Escape
  - Gas mask with organic vapor canister, with particulate filter
  - Self-contained breathing apparatus

Firefighting
- Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If formic acid gets into eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, flush with water. If it soaks through the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Physician examination
- Periodic exam following exposure
  - With emphasis on chronic respiratory disease
  - With emphasis on renal and liver functions
- Skin exam
- Eye disease check
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- EKG recommended if employee to wear full-face respirator

- Pulmonary functions
- Blood chemistry
- CBC

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Ventilate to disperse fumes
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- To evaporate, use fume hood

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- If body contact necessary, wear full protective gear
- Apply water spray to knock down vapors
- Vapor knockdown water is corrosive and should be contained

Waste Disposal

- Do not dump unneutralized substance in sewer due to explosivity.
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device.
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

FUMARIC ACID (9.1)

Occurrence

- Sizing resin modifier

Synonym(s)

- Boletic acid
- Lichenic acid
- Allomaleic acid
- Trans-butenedioic acid

Description

- Colorless, odorless crystals, fruit acid taste, combustible, low toxicity

Melting Point: 287°C (sealed tube)
Solubility in Water: 0.63 g/100 g water (25°C)
Specific Gravity: 1.635

FUMARIC ROSIN ESTER

Occurrence

- NOHS walk-through

GALLIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- 3,4,5-Trihydroxybenzoic acid

Description
- Colorless or slightly yellow crystalline needles or prisms, slightly soluble in water.

Specific Gravity: 1.694
Melting Point: 222°C-240°C

GASOLINE (-.4)

Occurrence
- NOHS walk-through

Synonym(s)
- Petrol
- Motor Spirits
- Benzin

Description
- Clear, volatile liquid with a characteristic odor, insoluble in water, combustible

Boiling Point: 37.7°C-204.4°C
Specific Gravity: 0.72-0.76
Permissible Exposure Limits in Air
- 300 ppm (900 mg/m^3) ACGIH
- STEL 500 ppm (1500 mg/m^3)

Registry Toxic Chemicals Number
- LX3300000

Route of Entry Into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Central nervous system depression
- Dermatitis
- Vesiculation
- Pheumonitis
- Kidney damage
- Intoxication
- Pulmonary edema
- Conjunctivitis
- Fatigue
- Asphyxia
- Drowsiness
- Cyanosis
- Hemorrhage
- Unconsciousness
- Respiratory distress

- Dry throat
- Eye irritation
- Headache

Target Organs
- Eyes
- Skin
- Lungs

Protective Equipment Requirements

Advise:
- Prevent repeated or prolonged skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent

Advise:
- Reasonable probability of eye contact (faceshield or vented goggles)

Work Clothing Should Be Changed Daily

Advise:
- Leaving clothing and equipment for decontamination and disposal

Remove Clothing

Advise:
- Promptly if it is non-impervious and contaminated

The Following Equipment Should Be Available

Advise:
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)

Advise:
  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:
- Promptly when skin becomes contaminated and at end of each work shift

First Aid
- If gasoline gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If gasoline gets on skin, immediately flush contaminated skin with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.

- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When gasoline has been swallowed, do not induce vomiting. Get medical attention immediately.

Medical Surveillance

No OSHA/NIOSH Data; exam not required but, due to hazardous nature of substance, advise following

- No exam required, unless employee to wear full facepiece respirator
- General medical history
- Industrial exposure history
- Respiratory history
- Pulmonary functions
- Periodic exam following exposure
- Skin exam
- Urinalysis
- Vision test
- Emphasis on central nervous system
- Emphasis on liver disease
- Blood chemistry
- Emphasis on chronic respiratory disease
- Pre-placement and annual exams
- 14 x 17 Chest P.A. X-ray

Leaks and Spill Procedures

No OSHA/NIOSH data; due to hazardous nature of substance, advise following

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- Stop flow of gas
- If liquid, use paper towels to absorb small quantities
- To evaporate, use fume hood
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Do not handle broken packages without protective equipment

Waste Disposal Methods

- Incineration
- For pits, lagoons, pools or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

GELATIN (9.1)

Occurrence
- Adhesive

Description
- Flakes or powder, odorless and tasteless, soluble in warm water, derived from same materials as animal glue, but specially treated for purer product

GLUTAMIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- alpha-Aminoglutaric acid
- 2-Amino pentanedioic acid

Description
- Crystals, nontoxic, DL-form moderately soluble in water

Specific Gravity: (DL-form) 1.4601 (20°C/4°C)
(L-form) 1.538 (20°C/4°C)
Melting Range: (DL-form) 225°C-227°C
(L-form) 247°C-249°C

GLYCEROL (9.1)

Occurrence
- Humectant

Synonym(s)
- Glycerin
- Glycyl alcohol
- 1,2,3-propanetriol

Description
- Clear, odorless, colorless, syrupy liquid, sweet taste, hygroscopic, soluble in water, low toxicity, combustible

Specific Gravity: 1.2653 (anhydrous)
Melting Point: 18°C
Boiling Point: 290°C

GLYCEROL MONOSTEARATE (9.1)

Occurrence
- Coating and lubricant

Synonym(s)
- GMS
- Glyceryl Monostearate
- Monostearin

Description
- Pure white or cream-colored, wax-like solid with faint odor, fatty but agreeable taste, affected by light, dispersible in hot water, combustible and nontoxic.

Specific Gravity: 0.97
Melting Point: 58°C-59°C

GLYOXAL (9.1)

Occurrence
- Humectant
- Component of polyacrylamide-glyoxal resin (wet-strength agent)

Description
- Yellow crystals or light yellow liquid, mild odor

Specific Gravity: 1.14 (20°C/20°C)
Melting Point: 15°C
Boiling Point: 51°C

GRAPHITE

Occurrence
- NOHS walk-through

Synonym(s)
- Plumbago
- Potelot
- Carbo minerals
- Black lead
- Carburet of iron
- Crayon noir
- Silver lead

Description
- Black greasy solid, odorless, low toxicity, insoluble in water

Boiling Point: 4826.6°C
Melting Point: 3350°C
Specific Gravity: 2.0-2.25
Permissible Exposure Limits in Air
- 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH

GUAR GUM (9.1)

Occurrence
- Binding agent and formation aid
- Wet-strength agent

Description
- Water-soluble plant mucilage, a polysaccharide. Yellowish-white powder, dispersible in hot or cold water, has 5-8 times the thickening power of starch, reduces friction drag on metals.

HELIUM

Occurrence
- NOHS walk-through

Description
- Colorless, odorless, tasteless gas or cryogenic liquid, non-combustible, asphyxiant

Boiling Point: -268.8°C
Solubility in Water, g/100 g water at 20°C: 0.0086
Melting Point: -287.2°C
Density: 0.1785 g/l at 0°C

HEPTANE

Occurrence
- NOHS walk-through

Synonym(s)
- Normal heptane
- Dipropyl methane
- Heptyl hydride

Description
- Colorless liquid with a mild gasoline-like odor, flammable

Boiling Point: 98.428°C
Solubility in Water, g/100 g water at 20°C: 0.005%
Melting Point: -91.1°C
Specific Gravity: 0.68368

Permissible Exposure Limits in Air
- 500 ppm (2000 mg/m^3)
- 85 ppm NIOSH TWA
- 440 ppm ceiling NIOSH
- 400 ppm (1,600 mg/m^3) ACGIH
- STEL 500 ppm (2,000 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 4250 ppm (17,382 mg/m^3)

Registry Toxic Chemicals Number
- MI7700000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Lightheadedness
- Giddiness
- Irritation of eyes, nose
- Dermatitis
- Unconsciousness
- Nausea
- Loss of appetite
- Stupor

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded

- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
- Reasonable probability of eye contact

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
- Eyewash

Respirator Selection (Upper Limit Devices Permitted)
- 850 ppm
  - Chemical cartridge respirator with organic vapor cartridge
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 4250 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes wet

First Aid
- If heptane gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If this chemical has been swallowed, do not induce vomiting. Get medical attention immediately.

Target Organs
- Skin
- Respiratory system
- Lungs
- Peripheral nervous system

Medical Surveillance
- EKG recommended if employee to wear full-face respirator
- General medical history
- Industrial exposure history

- Pre-placement and annual exams
- Skin exam
- Blood chemistry
- With emphasis on renal and liver functions
- With emphasis on kidney functions
- CBC
- Urinalysis
- Vision test
- Pulmonary functions
- Emphasis on respiratory history
- 14 by 17 chest P.A. X-ray

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- To evaporate, use fume hood
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Atomize in suitable safe combustion chamber
- Do not dump unneutralized substance in sewer due to explosivity
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

HEXACHLOROETHANE

Occurrence

- NOHS walk-through

Synonym(s)

- Perchloroethane

Description

- Colorless solid, camphor-like odor, noncombustible

Boiling Point: 189°C (sublimes)
Solubility in Water, g/100 g water at 20°C: 0.0005
Melting Point: 189°C (sealed tube)
Specific Gravity: 2.1

Permissible Exposure Limits in Air
- 1 ppm (10 mg/m^3) TWA OSHA
- 10 ppm (100 mg/m^3) (skin) ACGIH

Immediately Dangerous to Life or Health Concentration
- 300 ppm

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact
- Skin absorption

Symptoms
- CNS depression
- Narcosis
- Irritation of skin
- Irritation of mucous membranes
- Irritation of liver

Target Organs
- Eyes

Respirator Selection
- 10 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 50 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 300 ppm
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode or with full facepiece, helmet, or hood, operated in continuous flow mode
- Escape
  - Pesticide respirator
  - Self-contained breathing apparatus

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact

Work Clothing Should Be Changed Daily
- If it is possible that clothing is contaminated
- Remove clothing promptly if nonimpervious and contaminated

Employee Should Wash
- Promptly when skin becomes wet or contaminated and daily at the end of each work shift

First Aid
- If hexachloroethane gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids.
- If this chemical gets on skin, immediately wash with soap.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped perform artificial respiration.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of salt water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses

Waste Disposal Methods

- Incinerate after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produces.
- Liquid containing hexachloroethane should be absorbed in vermiculite, dry sand, earth, or a similar material.

HEXAMETHYLOLMELAMINE

Occurrence

- NOHS walk-through

Description

- Amorphous to crystalline white mass, soluble in water

Melting Range: 135°C-139°C

HEXANE (-.4)

Occurrence

- NOHS walk-through

Synonym(s)

- Hexyl hydride
- N-hexane

Description

- Colorless liquid with a mild gasoline-like odor, flammable, low toxicity

Boiling Point: 68.742°C

Solubility in Water, g/100 g water at 20°C: 0.014%

Melting Point: -95°C

Specific Gravity: 0.65937 (20°C/4°C)

Permissible Exposure Limits in Air

- 500 ppm (1800 mg/m^3)
- 100 ppm NIOSH TWA
- 510 ppm 15-minute ceiling
- 50 ppm TWA (180 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration

- 5,000 ppm

HEXYLENE GLYCOL

Occurrence

- NOHS walk-through

Synonym(s)

- 2,4-Dihydroxy-2-methylpentane
- Diolane
- 2-Methyl-2,4-pentanediol
- 1,2-Hexanediol

- 2-Methyl pentane-2,4-diol
- Pinakon
- Trimethyltrimethylene glycol

Description
- Colorless liquid with mild sweetish odor, soluble in water

Boiling Point: 197.7°C
Specific Gravity: 0.9216 (20°C/4°C)
Permissible Exposure Limits in Air
- 25 ppm (125 mg/m^3) ACGIH

HYDRAZINE (2.4)

(3.4)

Occurrence (4.4)
- Corrosion inhibitor in pulp mill power boilers (5.4)

Synonym(s) (6.4)
- Anhydrous Hydrazine
- Diamine
- Diamide

Description
- Colorless liquid with a weak ammonia-like odor, can be solid below melting point, soluble in water, carcinogen suspect

Boiling Point: 113.3°C
Melting Point: 2.2°C
Specific Gravity: 1.004
Permissible Exposure Limits in Air
- 1 ppm (1.3 mg/m^3)
- 0.03 (0.04 mg/m^3) NIOSH (2-hour period)
- 0.1 ppm (0.1 mg/m^3) TWA ACGIH (Skin)

Immediately Dangerous to Life or Health Concentration
- 80 ppm (105 mg/m^3)

Registry Toxic Chemicals Number
- MU7175000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Dry throat
- Irritation of eyes, nose
- Visual disturbance
- Dizziness
- Nausea
- Dermatitis
- Skin Burn
- Bronchitis
- Pulmonary edema
- Hematopoietic degeneration
- Kidney damage
- Liver damage
- Blood changes
- Central nervous system depression

Target Organs
- Central nervous system
- Respiratory system
- Skin
- Eyes
- Blood

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 10 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 50 ppm
  - Supplied-air respirator with full face-piece, helmet or hood
  - Self-contained breathing apparatus with full face-piece
- 80 ppm
  - Type C supplied-air respirator with full face-piece operated in pressure demand or positive-pressure mode with full face-piece, helmet, or hood operated in continuous flow mode
- Escape
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full face-piece operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If hydrazine gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If it gets on skin, immediately flush skin with water. If this chemical penetrates clothing immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped perform artifical respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- EKG recommended if employee to wear full-face respirator
- General medical history
- Industrial exposure history
- Pre-placement and annual exams
- CNS tests (peripheral neuropathy)
- Respiratory history
- Pulmonary functions
- Blood chemistry with emphasis on
  - Renal and liver functions, kidneys
- Skin exam
- 14 by 17 chest P.A. X-ray
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warning to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Remove ignition sources
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- Wear full protective clothing (fireman's gear inadequate)
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Absorb in vermiculite, dry sand, earth or similar material and then place in sealed containers in secured sanitary landfill
- Collect solid substance in most safe way for reclamation
- Do not dump unneutralized substance in sewer due to explosivity
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

HYDROGEN CHLORIDE

(2.1)
(3.1)
(4.1)
(5.1)

Occurrence

- Preparation of chlorine dioxide

Synonym(s)

- Anhydrous hydrochloric acid

- Muriatic acid
- H.C.L.

Description
- Colorless gas with an irritating, pungent odor, noncombustible

Boiling Point: -85°C
Solubility in Water, g/100 g Water at 20°C: 62%
Melting Point: -113.88°C

Permissible Exposure Limits in Air
- 5 ppm (7 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 100 ppm (151 mg/m^3)

Registry Toxic Chemicals Number
- MW9610000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Inflammation
- Nose irritation
- Dry throat
- Cough
- Eye inflammation
- Skin burn
- Dermatitis

Target Organs
- Respiratory system
- Lungs
- Eyes
- Skin

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minumum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing Should Be Changed Daily
- If there is any possibility that clothing may be contaminated

Remove Clothing
- Immediately if it becomes wet or if it is non-impervious and becomes contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 50 ppm
  - Chemical cartridge respirator, with acid gas cartridge
  - Supplied-air respirator

    - Self-contained breathing apparatus
- 100 ppm
    - Chemical cartridge respirator, with acid gas cartridge, with full facepiece
    - Gas mask with acid gas canister, chin-style or front- or back-mounted
    - Supplied-air respirator with full facepiece, helmet, or hood
    - Self-contained breathing apparatus with full facepiece
- Escape
    - Gas mask with acid gas canister, chin-style or front- or back-mounted
    - Self-contained breathing apparatus
- Firefighting
    - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Immediately when skin becomes contaminated with liquid of pH less than 3 and promptly when skin becomes wet with liquid of pH greater than 3

First Aid

- If hydrogen chloride (hydrochloric acid) gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it penetrates clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If the chemical has been swallowed and the person is conscious, immediately give him large quantities of water to dilute the chemical. DO NOT attempt to make the exposed person vomit. Get medical attention immediately.

Medical Surveillance

- EKG recommended if employee to wear full-face respirator
- General medical history
- Industrial exposure history
- Physician examination
- Emphasis on skin and eye disease
- Urinalysis
- Vision test
- CBC
- Blood chemistry
- 14 by 17 chest P.A. X-ray
- Pre-placement and annual exams

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Stop flow of gas
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- Keep out of water sources and sewers
- Use water spray to knock down vapors

- Vapor knockdown water is corrosive and should be contained
- Neutralize spilled material with crushed limestone, soda ash or lime
- Do not use water on material itself

Personal Danger Situation Protection
- Avoid breathing vapors
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- Wear full protective clothing (firemans gear inadequate)
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Soda ash-slaked lime is added to form the neutral solution of chloride of sodium and calcium. This solution can be discharged after dilution with water; alternatively, hydrogen chloride can be recovered from a variety of process waste streams.

HYDROGEN PEROXIDE (2.1)

(3.1)

Occurrence (4.1)
- Oxidative bleaching for mechanical pulps, (also used (5.1)
  in chemical bleaching) (6.1)
- Deinking (8.1)

Synonym(s)
- Hydrogen dioxide
- Albone
- Inhibine
- Perhydrol

Description
- Colorless liquid with a slightly sharp odor, miscible in water, noncombustible

Boiling Point: 141.1°C
Melting Point: -22°C

Permissible Exposure Limits in Air
- 1 ppm (1.5 mg/m^3)
- STEL 2 ppm (3 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 75 ppm (104 mg/m^3)

Registry Toxic Chemicals Number
- MX0900000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Eyes, nose irritation
- Dry throat
- Cornea inflammation
- Erythema
- Vesiculation

Target Organs
- Eyes
- Respiratory system
- Skin

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minumum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Remove Clothing
- Immediately if it is non-impervious and becomes contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 10 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
  - Do not use oxidizable filters
- 50 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
  - Do not use oxidizable filters
- 75 ppm
  - Type C supplied-air respirator operated in pressure demand, positive-pressure or continuous flow mode
  - Do not use oxidizable filters
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
  - Use full facepiece when eye or facial irritation present
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated

First Aid
- If hydrogen peroxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it penetrates clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped perform artificial respiration.

Keep the affected person warm and at rest. Get medical attention as soon as possible.

- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
  - With emphasis on eye disease
  - With emphasis on respiratory history
- Pulmonary functions
- Skin exam
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Urinalysis
- Vision test

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Keep material out of water sources and sewers

Personal Danger Situation Protection

- Keep upwind
- Avoid breathing vapors
- Wear boots, protective gloves and gas-tight goggles
- Avoid bodily contact with material
- If body contact necessary, wear full protective gear
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Dilute with large quantities of water and flush into sewer
- Dispose of substance in RCRA approved disposal facility
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

HYDROGEN SULFIDE (2.2) (4.1)

Occurrence

- Major kraft pulping process gaseous emission
- Source of sulfur for preparation of sulfite liquor

Synonym(s)

- Sulfretted hydrogen
- Hydrosulfuric acid
- Hepatic acid

Description

- Colorless gas, strong rotten eggs odor

Boiling Point: -60°C
Solubility in Water, g/100 g water at 20°C: 2.9%
Melting Point: -82.7°C
Permissible Exposure Limits in Air
- 20 ppm (30 mg/m^3)
- 50 ppm 10 min peak (75 mg/m^3) 8-hour period
- 10 ppm 10 min peak NIOSH (15 mg/m^3)
- 50 ppm (Evacuation) (70 mg/m^3)
- 10 ppm ACGIH (14 mg/m^3) ACGIH TWA
- STEL 15 ppm (21 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 300 ppm (417 mg/m^3)

Registry Toxic Chemicals Number
- MX1225000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Unconsciousness
- Coma
- Convulsions
- Eye irritation
- Conjunctivitis
- Lacrimation
- Photophobia
- Vesiculation of cornea
- Irritability
- Pulmonary irritation
- Dizziness
- Headache
- Fatigue
- Insomnia
- Gastrointestinal pain

Target Organs
- Blood
- White blood cells
- Mucous tissue

Protective Equipment Requirements
- Prevent skin contact
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

Wear Eye Protection to Prevent
- Any possibility of eye contact

Respirator selection (Upper Limit Devices Permitted)
- 300 ppm
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece

- Escape
  - Gas mask with acid gas canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid

- If hydrogen sulfide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately flush skin with water. If irritation persists after washing, get medical attention immediately.
- If a person breathes in large amounts of the chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- CNS tests (peripheral neuropathy)
- CBC
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- Pulmonary functions
- EKG recommended if employee to wear full-face respirator

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Ventilate to disperse fumes/gasses
- Stop flow of gas
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- If liquid, allow to evaporate
- Apply water spray to knock down vapors
- Vapor knockdown water is toxic and should be contained

Personal Danger Situation Protection

- Keep upwind
- Avoid breathing vapors
- Wear self-contained breathing apparatus
- Wear full protective clothing (fireman's gear inadequate)
- Do not handle broken packages without protective equipment
- Approach fire with caution
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Method

- Incineration, recovery

HYDROXYETHYLCELLULOSE (9.1)

Occurrence
- Sizing agent

Synonym(s)
- "Cellosize"

Description
- Non-ionic, water-soluble cellulose ether, white, free-flowing powder, combustible and nontoxic

Specific Gravity: 1.07-1.18
Softening Range: 100°C-130°C

HYDROXYETHYLETHYLENEDIAMINE

Occurrence
- NOHS walk-through

Synonym(s)
- Aminoethylethanolamine

Description
- Hygroscopic liquid, mild, ammoniacal odor, soluble in water, combustible, low toxicity

Specific Gravity: 1.0304 (20°C/20°C)
Boiling Point: 243.7°C
Registry Toxic Chemicals Number
- KJ6300000

HYDROXYETHYL STARCH (9.1)

Occurrence
- Sizing agent

Synonym(s)
- Hetastarch
- Starch 2-hydroxyethyl ether

Description
- Starch derivative of undetermined exact composition (prepared by treating starch with pyridine and ethylene chlorohydrin)

IODINE

Occurrence
- NOHS walk-through

Description
- Violet solid with a sharp, characteristic odor, highly toxic, strong irritant

Boiling Point: 184°C
Solubility in Water, g/100 g water at 20°C: 0.03%
Melting Point: 113.5°C
Specific Gravity: 4.98
Permissible Exposure Limits in Air
- 0.1 ppm (1 mg/m^3) ceiling

IRON BLUE (9.1)

Occurrence
- Pigment

Synonym(s)
- Prussian blue

Description
- Insoluble in water, low toxicity, prepared by precipitation (and subsequent oxidation) of ferrous ferrocyanide from soluble ferrocyanide and ferrous sulfate

IRON OXIDE (9.1)

Occurrence
- Pigments

Synonym(s)
- Ferric oxide fume
- Red oxide D6984
- 11554 red
- Jewelers rouge
- Burnt senna
- C.I. 77491
- C.I. pigment red 101
- Deanox

Description
- Red-brown fumes with a metallic taste

Boiling Point: 2771.1°C
Melting Point: 1538°C
Specific Gravity: 5.18
Permissible Exposure Limits in Air
- 10 mg/m^3 (1.5 ppm)
- 5 mg/m^3 ACGIH
- STEL 10 mg/m^3

Registry Toxic Chemicals Number
- NO7525000

IRON SILICATE

Occurrence
- NOHS walk-through

ISOBUTANE

Occurrence
- NOHS walk-through

Synonym(s)
- 2-methylpropane
- Trimethylmethane

Description
- Colorless gas, slight odor, soluble in water, combustible, nontoxic

Specific Gravity: 0.5572 (20°C at saturation pressure)
Boiling Point: -11.73°C

ISOOCTYL(2,4-DICHLOROPHENOXY)ACETATE

Occurrence
- NOHS walk-through

ISOPHORONE (2.2)

Occurrence
- Final effluent

Permissible Concentrations in Water
- 117,000 micrograms/l (freshwater)
- 12,000 micrograms/l (saltwater)
- 5,200 micrograms/l (human)

Permissible Exposure Limits in Air
- 25 ppm (140 mg/m^3)
- 5 ppm ceiling (25 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 800 ppm

Registry Toxic Chemicals Number
- GW7700000

ISOPHTHALIC ALKYD RESIN

Occurrence
- NOHS walk-through

Description
- Type of polyester resin obtained from reaction of ethylene glycol or glycerol and isophthalic acid in the presence of a drying oil

ISOPIMARIC ACID (-.2)

Occurrence
- Final effluent

ISOPRENE

Occurrence
- NOHS walk-through

Synonym(s)
- 3-methyl-1,3-butadiene
- 2-methyl-1,3-butadiene

Description
- Colorless, volatile liquid, insoluble in water, combustible moderately toxic, irritant

Specific Gravity: 0.6808 (20°C/4°C)
Boiling Point: 34.08°C

ISOPROPYL ACETATE

Occurrence
- NOHS walk-through

Synonym(s)
- Sec-propyl acetate

Description
- Colorless liquid with a fruity odor

Boiling Point: 89.4°C
Solubility in Water, g/100 g water at 20°C: 2.9%
Melting Point: -68.8°C
Specific Gravity: 0.8690 (25°C/4°C)
Permissible Exposure Limits in Air
- 250 ppm (950 mg/m^3)
- Stel 310 ppm (1,185 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 16,000 ppm (66,748 mg/m^3)

Registry Toxic Chemicals Number
- AI4930000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Irritation of eyes(s) nose
- Dry throat
- Unconsciousness
- Dermatitis
- Irritation of skin

Target Organs
- Respiratory system
- Eyes
- Skin

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 1,000 ppm
  - Chemical cartridge respirator with organic vapor cartridge and full facepiece
- 5,000 ppm
  - Gas mask with organic vapor canister, chin style
- 12,500 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 16,000 ppm
  - Supplied-air respirator with full facepiece, operated in pressure demand, positive-pressure or continuous flow mode
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated

First Aid
- If isopropyl acetate gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, immediately get medical attention. If medical attention is not available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance
- Physician exam
- General medical history
- Industrial exposure history
- Respiratory history
- Skin exam
- Blood chemistry
- With emphasis on renal and liver functions
- Vision test
- Urinalysis
- EKG recommended if employee to wear full-face respirator

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep material out of water sources and sewers
- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors
- Attempt to stop leak if without hazard

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Do not dump unneutralized substance in sewer due to explosivity
- Atomize in suitable safe combustion chamber
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ISOPROPYL ALCOHOL (9.1)

Occurrence

- Slime control agent
- Oil-resistance paper additive

Synonym(s)

- Isopropanol
- IPA
- Lutosol
- Petrohol
- Dimethylcarbinol
- PRO
- Avantin

Description

- Colorless liquid with an odor of rubbing alcohol, miscible in water, combustible, carcinogen suspect

Boiling Point: 82.2°C

Melting Point: -88.8°C

Permissible Exposure Limits in Air

- 400 ppm (980 mg/m^3)
- 400 ppm TWA NIOSH, 800 ppm 8-hour ceiling
- STEL 500 ppm (1,225 mg/M3)

Immediately Dangerous to Life or Health Concentration
- 20,000 ppm (49,079 mg/M3)

Registry Toxic Chemicals Number
- NT8050000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Eye, nose irritation
- Dry throat
- Drowsiness
- Dizziness
- Headache
- Dermatitis
- Gastrointestinal pain
- Nausea
- Diarrhea

Target Organs
- Eyes
- Skin
- Respiratory system

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Work Clothing Should Be Changed Daily
- If there is any possibility that clothing may be contaminated

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 1,000 ppm
    - Chemical cartridge respirator with organic vapor cartridge with full facepiece
- 5,000 ppm
    - Gas mask with chin-style organic vapor canister
- 20,000 ppm
    - Gas mask with organic vapor canister, front- or back-mounted
    - Supplied-air respirator with full facepiece, helmet, or hood
    - Self-contained breathing apparatus with full facepiece

- Escape
    - Gas mask with organic vapor canister, chin-style or front- or back-mounted
    - Self-contained breathing apparatus
- Firefighting
    - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes wet

First Aid

- If isopropyl alcohol gets into the eyes, immediately wash the eyes with large amounts of water occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it penetrates clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, immediately get medical attention. If medical attention is not available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- Physician examination
- EKG Recommended if employee to wear fullface respirator
- General medical history
- Industrial exposure history
- Blood chemistry with emphasis on renal and liver functions
- Skin exam
- Kidneys
- Respiratory history
- Pulmonary functions
- Pre-placement and annual exams
- CBC
- Urinalysis
- 14 by 17 Chest P.A. X-ray
- Vision test
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger

- To evaporate, use fume hood
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Build dikes to contain flow as necessary
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Avoid breathing vapors or dust
- Keep upwind
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Atomize in suitable safe combustion chamber
- Do not dump unneutralized substance in sewer due to explosivity
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA. (RCRA).

KEROSENE (9.1) (-.4)

Occurrence
- Pitch control agent
- Foam control agent

Synonym(s)
- Kerosine

Description
- Watery-white, oily liquid mixture of petroleum hydrocarbons, combustible

Specific Gravity: 0.81

Boiling Range: 180°C-300°C

Registry Toxic Chemicals Number
- OA5500000

Routes of Entry
- Ingestion
- Skin contact
- Inhalation

Target Organs
- Lungs
- Skin

Symptoms
- Skin irritation/infection
- Bronchopneumonia (may be fatal)
- Gastrointestinal irritation
- Nausea
- Vomiting

KAOLIN (9.1)

Occurrence
- Pigment filler/coating

Synonym(s)
- Aluminum silicate
- China clay

Description
- White to yellowish-grayish fine powder, insoluble in water, darkens and develops clay odor when damp (becomes slippery). Composed of alumina, silica, water, impurities, is nontoxic and noncombustible

Specific Gravity: 1.8-2.6

LACTOL SPRITS

Occurrence
- NOHS walk-through

LATEX (9.1)

Occurrence
- Adhesive
- Wet-strength/dry-strength agent

Description
- Natural - white, tacky aqueous suspension of a hydrocarbon polymer, comprised of irregularly-shaped globules
- Synthetic - colloidal suspension (much smaller particles) obtained by emulsion polymerization of certain polymers and resins

LEAD (-.2)
(9.1)

Occurrence
- Pigments
- Final effluent

Synonym(s)
- White lead
- C.I. pigment metal 4
- C.I. 77575
- Lead flake

Description
- Variable in description to particular compound. Toxic by ingestion and inhalation, insoluble in water, teratogen suspect

Boiling Point: 1755°C
Melting Point: 327.4°C
Specific Gravity: 11.35

Permissible Concentration in Water
- 668 micrograms/l (saltwater, acute)
- 25 micrograms/l (saltwater, chronic)
- 50 micrograms/l (human)

Permissible Exposure Limits in Air
- 50 micrograms/m^3

Registry Toxic Chemicals Number
- OF7525000

LEAD CARBONATE

Occurrence
- NOHS walk-through

Synonym(s)
- Lead subcarbonate
- White lead
- Lead flake

Description
- White, amorphous powder, insoluble in water, noncombustible

Specific Gravity: 6.86

Permissible Exposure Limits in Air
- 0.15 mg/m^3 (as lead)

LEAD DIOXIDE

Occurrence
- NOHS walk-through (as lead oxide)

Synonym(s)
- Lead oxide, brown
- Plumbic acid, anhydrous
- Lead superoxide
- Lead peroxide

Description
- Brown, hexagonal crystals, insoluble in water, toxic

Specific Gravity: 9.375

Melting Point: 290°C (Decomposes)

Permissible Exposure Limits in Air
- 0.15 mg/m^3 (as lead)

LEAD FLUORIDE

Occurrence
- NOHS walk-through

Description
- Colorless crystals, slightly soluble in water, noncombustible.

Density: 8.2 g/cc

Melting Point: 824°C

Permissible Exposure Limit in Air
- 0.15 mg/m^3 (as lead)

LEAD HYDROXIDE

Occurrence
- NOHS walk-through (as lead oxide)

Synonym(s)
- Lead hydrate
- Hydrated lead oxide

Description
- White, bulky powder, slightly soluble in water, noncombustible, toxic

Specific Gravity: 7.592
Melting Point: 145°C (Decomposes)
Permissible Exposure Limits in air
- 0.15 mg/m^3 (as lead)

LEAD MOLYBDATE (9.1)

Occurrence
- Pigments

Synonym(s)
- Sulfenite
- Lead chromic acid+molybdenum salt
- C.I. pigment red 104
- Molybdenum orange

Description
- White to pale yellow odorless solid, noncombustible, toxic, insoluble in water

Boiling Point: Decomposes
Melting Range: 1060°C-1070°C
Specific Gravity: 5.9
Permissible Exposure Limits in Air
- 1 ppm (15 mg/m^3)
- 10 mg/m^3 ACGIH

LEAD NAPHTHENATE

Occurrence
- NOHS walk-through

Description
- Soft, yellow, resinous semi-transparent solid, combustible, toxic, abosrbed by skin, known carcinogen

Melting Point: 100°C

LEAD OLEATE

Occurrence
- NOHS walk-through

Description
- White powder or ointment-like granules or mass, insoluble in water, combustible, toxic, absorbed by skin

LEAD OXIDE, RED

Occurrence
- NOHS walk-through (as lead oxide)

Synonym(s)
- Red lead
- Minium
- Lead tetroxide

Description
- Bright red powder, insoluble in water, toxic

Specific Gravity: 8.32-9.16
Melting Point: 500°C-530°C (Decomposes)
Permissible Exposure Limits in Air
- 0.15 mg/m^3 (as lead)

LEAD SUBOXIDE

Occurrence
- NOHS walk-through (as lead oxide)

Synonym(s)
- Lead oxide, black
- Litharge, leaded

Description
- Black, amorphous material, insoluble in water, toxic

Specific Gravity: 8.342
Melting Point: Decomposes with heat
Permissible Exposure Limits in Air
- 0.15 mg/m^3 (as lead)

LEAD SULFATE

Occurrence
- NOHS walk-through

Description
- White, rhombic crystals, slightly soluble in hot water, toxic and noncombustible

Specific Gravity: 6.12-6.39
Melting Point: 1170°C
Permissible Exposure Limits in Air
- 0.15 mg/m^3 (as lead)

LECITHIN (9.1)

Occurrence
- Emulsifier and dispersion agent

Description
- Light brown to brown viscous semiliquid, characteristic odor, nontoxic

LIGNIN

(-.3)
(9.1)

Occurrence
- Dispersant (pulping by-product)

Description
- Polymer comprising 17-30% of wood, carried throughout the pulping process and recovered on a limited basis.

LIGNIN SULFONATE

(4.3)
(9.1)

Occurrence
- Dispersant (recovered from sulfite liquor)

Synonym(s)
- Lignosulfonate

Description
- Light-tan to dark-brown powder, no pronounced odor, forms colloidal solutions or dispersions in water, nonhygroscopic.

Specific Gravity: 1.5

LIMONENE

Occurrence
- NOHS walk-through

Description
- Colorless liquid (D- and L-forms)

Specific Gravity: 0.8411-0.8422 (20°C)
Boiling Point: 176°C-176.4°C

LINOLEIC ACID

(-.2)

Occurrence
- NOHS walk-through
- Final effluent

Synonym(s)
- Linolic acid
- 9,12-Linoleic acid

Description
- Polyunsaturated fatty acid, colorless to straw-colored liquid, insoluble in water, combustible and nontoxic.

Specific Gravity: 0.905 (15°C/4°C)
Boiling Point: 228°C (14 mm)
Registry Toxic Chemicals Number
- RF9990000

LINOLENIC ACID

(2.2)
(3.2)
(4.2)
(5.2)

Occurrence
- Final effluent

Description (6.2)
- Polyunsaturated fatty acid, insoluble in water, (7.2)
  combustible (8.2)
  (10.2)

LINSEED ALKYD (9.1)

Occurrence
- NOHS walk-through (coating)

Description
- Type of polyester resin obtained from reaction of a dihydric or polyhedric alcohol and a polybasic acid, in the presence of a drying oil (linseed, in this case)

LINSEED OIL (9.1)

Occurrence
- NOHS walk-through (linseed alkyd resin)

Synonym(s)
- Flaxseed oil

Description
- Golden-yellow, amber or brown drying oil with peculiar odor and bland taste, combustible

Specific Gravity: 0.931-0.936

LITHARGE

Occurrence
- NOHS walk-through

Synonym(s)
- Lead oxide, yellow
- Plumbous oxide
- Lead monoxide

Description
- Yellow crystals, insoluble in water, toxic by ingestion and inhalation

Specific Gravity: 9.53
Melting Point: 888°C
Permissible Exposure Limits in Air
- 0.15 mg/m^3 (as lead)

LITHIUM CHLORIDE

Occurrence
- NOHS walk-through

Description
- White deliquescent crystals, very soluble in water, very hygroscopic, low toxicity

Specific Gravity: 2.068
Melting Point: 614°C
Boiling Point: 1360°C

LITHIUM GREASE (-.4)

Occurrence
- Lubricant

Description
- A grease using a lithium soap of the higher fatty acids as a base, water-resistant.

LITHIUM HYDROXIDE

Occurrence
- NOHS Walk-through

Description
- Colorless crystals, soluble in water, toxic, strong irritant in solution

Specific Gravity: 2.54
Melting Point: 470°C
Boiling Point: 924°C

MAGNESIUM

Occurrence
- NOHS walk-through

Description
- Silvery, moderately hard metal, insoluble in water, dangerous fire hazard

Specific Gravity: 1.74
Melting Point: 650°C
Boiling Point: 1107°C

MAGNESIUM ALUMINUM SILICATE (9.1)

Occurrence
- Pigment filler/coating

Synonym(s)
- Aluminum magnesium silicate (hydrated)
- Attapulgite

Description
- Type of clay (component of fuller's earth)

MAGNESIUM CARBONATE

Occurrence
- NOHS walk-through

Description
- Light, bulky white powder, slightly soluble in water, nontoxic and noncombustible

Specific Gravity: 3.0

MAGNESIUM CHLORIDE

Occurrence
- NOHS walk-through

Description
- Colorless or white crystals, deliquescent, soluble in water, combustible, moderately toxic by ingestion.

Specific Gravity: 2.32
(hexahydrate) 1.56
Melting Point: 708°C
(hexahydrate) 116°C-118°C
Boiling Point: 1412°C
(hexahydrate) Decomposes

MAGNESIUM HYDROXIDE (4.1)

Occurrence
- Preparation of magnesium-base sulfite pulp liquor

Synonym(s)
- Magnesium hydrate
- Milk of magnesia

Description
- Odorless white powder, almost insoluble in water, nontoxic and noncombustible

Specific Gravity: 2.36
Melting Point: 350°C (Decomposes)

MAGNESIUM OXIDE (4.1)

Occurrence
- Chemical make-up in the formation of magnesium bisulfite pulping liquor

Synonym(s)
- Magnesia

Description
- White powder, may be light or heavy, slightly soluble in water, noncombustible

Boiling Point: 3582°C (solid)
Melting Point: 2800°C (solid)
Specific Gravity: 3.58 (solid) (varies)
Permissible Exposure Limits in Air
- 15 mg/m^3 NIOSH
- 10 mg/m^3 TWA ACGIH

Registry Toxic Chemicals Number
- OM3850000

Route of Entry Into Body
- Inhalation
- Eye contact

Symptoms
- Eye and nose irritation
- Chills

- Fever
- Headache
- Tightness of chest
- Cough
- Weakness
- Fatigue
- Dryness of nose and mouth
- Muscular pain
- Nausea
- Vomiting

Target Organs
- Eyes and nose
- Lungs

Protective Equipment Requirements
- Avoid skin and eye contact

Wear Eye Protection to Prevent
- Any possibility of eye contact

Respirator Selection
- 150 mg/m^3
  - Fume respirator or high-efficiency particulate filter respirator
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 750 mg/m^3
  - High-efficiency particulate filter respirator with full facepiece
  - Supplied-air respirator with a full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- 7500 mg/m^3
  - Powered air-purifying respirator with a high-efficiency particulate filter
  - Type C supplied-air respirator operated in pressure demand or positive-pressure or continuous flow mode
- Escape
  - Self-contained breathing apparatus with a full facepiece operated in pressure demand or positive-pressure mode
  - Combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure demand or positive-pressure or continuous-flow mode
  - Auxilliary self-contained breathing apparatus operated in pressure demand or other positive-pressure mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

First Aid
- If a person breathes in large amounts of magnesium oxide move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance
- General medical history
- Respiratory disease history

Leaks and Spill Procedures
- Persons not wearing protective equipment and clothing should be restricted from areas of release until cleanup has been completed

- If potentially hazardous amounts of magnesium oxide fume are inadvertently released, ventilate the area of release to disperse the fumes.

Waste Disposal Methods
- Incineration

MAGNESIUM SILICATE (9.1)

Occurrence
- Filler and pitch control agent

Description
- Fine white powder, insoluble in water, noncombustible, may be toxic by inhalation

MAGNESIUM SULFATE (2.1) (3.1) (4.1) (5.1) (6.1)

Occurrence
- Oxidative mechanical bleaching or chemical bleaching with hydrogen peroxide (inhibits hydrogen peroxide decomposition)

Synonym(s)
- Epsom salts

Description
- Colorless crystals, low toxicity

Specific Gravity: 1.678

MALEIC ANHYDRIDE (9.1)

Occurrence
- Starting material for styrene-maleic anhydride copolymer (sizing and dry-strength agent)

Synonym(s)
- 2,5-Furanedione
- Toxilic anhydride

Description
- White solid with penetrating odor, insoluble in water

Boiling Point: 200°C
Melting Point: 53°C
Specific Gravity: 0.934 (20°C/4°C)
Permissible Exposure Limits in Air
- 0.25 ppm (1 mg/m^3)

Registry Toxic Chemicals Number
- ON3675000

MANGANESE LINOLEATE

Occurrence
- NOHS walk-through

Description
- Dark brown, plaster-like mass, combustible

MANGANIC HYDROXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Manganese hydroxide
- Hydrated manganic oxide

Description
- Brown powder, insoluble in water

Specific Gravity: 4.2-4.4

MANGANOUS SULFATE

Occurrence
- NOHS walk-through

Synonym(s)
- Manganese sulfate

Description
- Translucent, pale rose-red, efflorescent prisms, soluble in water

Specific Gravity: 2.107

Melting Point: 30°C
700°C (Anhydrous)

MELAMINE-FORMALDEHYDE RESIN (9.1)

Occurrence
- Wet strength agent
- Humectant

Description
- An amino resin made from melamine and formaldehyde, may be water soluble syrup or insoluble powder which is dispersible in water.

MERCURY (-.2) (2.2)

Occurrence
- Final effluent
- Oil-fired power boilers (particulate)

Description
- Mercuric salts are variably soluble in water, toxic by inhalation, ingestion, skin absorption

Permissible Exposure Limits in Air
- 0.1 mg/m^3 (ceiling)
- 0.05 mg/m^3 TWA NIOSH and ACGIH
- STEL 0.15 mg/m^3 ACGIH

Immediately Dangerous to Life or Health Concentration
- 28 mg/m^3

Permissible Concentrations in Water
- 0.00057 micrograms/l (freshwater, 24-hour average)
- 0.0017 micrograms/l (freshwater, ceiling)
- 0.025 micrograms/l (saltwater, 24-hour average)
- 3.7 micrograms/l (saltwater, ceiling)
- 0.144 micrograms/l (human)

(2-METHACRYLOYLOXYETHYL)-TRIMETHYLAMMONIUM SALT (9.1)

Occurrence
- Retention aid

METHANE

Occurrence
- NOHS walk-through

Synonym(s)
- Methyl hydride
- Marsh gas
- Fire damp
- Natural gas
- Gas

Description
- Colorless, odorless, tasteless gas, usually scented with mercaptan substance with noxious odor, asphyxiant, slightly soluble in water

Boiling Point: -161.6°C
Melting Point: -183.2°C
Specific Gravity: 0.554

METHYL ACETATE

Occurrence
- NOHS walk-through

Synonym(s)
- Acetic acid methyl ester

Description
- Colorless liquid, fruity odor, combustible

Boiling Point: 54.05°C
Solubility in Water, g/100 g Water at 20°C: 24.5
Melting Point: -97.7°C
Specific Gravity: 0.92438
Permissible Exposure Limits in Air
- 200 ppm (610 mg/m^3)
- STEL 250 ppm (760 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 10,000 ppm

METHYL ALCOHOL

(2.1)
(3.1)
(4.1)
(5.1)

Occurrence
- Chlorine dioxide preparation (Solvay process)

Synonym(s)
- Methanol
- Wood alcohol
- Carbinol
- Columbian spirts

Description
- Clear liquid, alcohol odor, miscible in water, combustible

Boiling Point: 64.5°C

Melting Point: -97.7°C

Permissible Exposure Limits in Air
- 200 ppm (260 mg/m^3)
- 262 mg/m^3 TWA (10-hour) NIOSH
- 800 ppm NIOSH (1,048 mg/m^3) (15 minutes) (skin)
- STEL 250 ppm (310 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 25,000 ppm (32,700 mg/m^3)

Registry Toxic Chemicals Number
- PC1400000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Burning and irritation of eyes
- Headache
- Drowsiness
- Lightheadedness
- Nausea
- Vomiting
- Visual disturbance
- Ataxia
- Liver damage
- Blindness

Target Organs
- Eyes
- Skin
- Central nervous system
- Gastrointestinal system

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Remove Clothing
- Promptly if it is non-impervious and contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash

Respirator Selection (Upper Limit Devices Permitted)
- 2,000 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 10,000 ppm
  - Supplied-air respirator with full facepiece
  - Self-contained breathing apparatus with full facepiece
- 25,000 ppm
  - Type C supplied-air respirator with full facepiece, helmet, or hood, operated in pressure demand, positive-pressure or continuous flow mode
- Escape
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If methyl alcohol gets into eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, flush skin with water. If it soaks through the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
  - With emphasis on renal and liver functions
- Skin exams
- Vision exams

- Urinalysis
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- EKG recommended if employee to wear full-face respirator

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Remove ignition sources
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- To evaporate, use fume hood

Personal Danger Situation Protection

- Keep upwind
- Avoid breathing vapors
- Wear boots, protective gloves and gas-tight goggles
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Do not handle broken packages without protective equipment

Waste Disposal

- Atomize in suitable safe combustion chamber
- Absorb in vermiculite, dry sand, earth or similar material and then place in sealed containers in secured sanitary landfill.
- Do not dump unneutralized substance in sewer due to explosivity
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

METHYLAMINE

Occurrence

- NOHS walk-through

Synonym(s)

- Monomethylamine
- Aminomethane

Description

- Colorless gas, strong ammoniacal odor, soluble in water, combustible, toxic, strong tissue irritant.

Boiling Point: -6.79°C

Permissible Exposure Limits in Air

- 10 ppm 8-hour TWA OSHA and NIOSH

N-METHYL DITHIOCARBAMATE (9.1)

Occurrence

- Biocide/slime control agent

METHYLENBIS(NAPHTHALENE SULFONATE)

Occurrence
- NOHS walk-through

METHYLENE CHLORIDE (-.2)

Occurrence
- NOHS walk-through
- Final effluent

Synonym(s)
- Dichloromethane
- Methylene Dichloride
- Solaesthin
- Aerotherm

Description
- Colorless liquid with a chloroform-like odor, slightly soluble in water, carcinogen suspect

Boiling Point: 40.1°C

Melting Point: -96.7°C

Specific Gravity: 1.335 (15°C/4°C)

Permissible Concentration in Water
- Preferably zero (human)

Permissible Exposure Limits in Air
- 500 ppm 8-hour TWA, 1,000 ceiling, 2,000 5-minute peak
- 100 ppm (360 mg/m^3) ACGIH TWA
- 75 ppm 10-hour TWA, 500 ppm 15-minute ceiling NIOHS
- STEL 500 ppm (1700 mg/m^3) ACGIH

Immediately Dangerous to Life or Health
- 5,000 ppm

Registry Toxic Chemicals Number
- PA8050000

Route of Entry Into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Fatigue
- Weakness
- Sleepiness
- Lightheadedness
- Numbness of extremities
- Headache
- Irritation eye(s) or skin
- Vertigo
- Angina pectoris
- Central nervous system depression
- Peripheral neuropathy disturbance

Target Organs
- Skin
- Cardiovascular system

- Eyes
- Central nervous system

Protective Equipment Requirements

- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Prevent repeated or prolonged skin contact
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent

- Reasonable probability of eye contact

Remove Clothing

- Promptly if it is non-impervious and contaminated

The Following Equipment Should Be Available

Advise:

- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 5000 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes wet

First Aid

- If methylene chloride gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in

the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- CBC
- Blood chemistry
- 14 x 17 chest P.A. X-ray
- EKG recommended if employee to wear full-face respirator
- Vision test
- Urinalysis
- General medical exam
  - With emphasis on liver disease
  - With emphasis on kidney disease
- Cardiovascular disease
- Blood cell morphology (differential)
- Carboxyhemoglobin determination when exposed
  - With emphasis on central nervous system
- Pulmonary functions
  - With emphasis on chronic respiratory disease
- Emphasis on renal and liver functions
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus
- If body contact necessary, wear full protective gear

Waste Disposal Methods

- Absorb in vermiculite, dry sand, earth or similar material and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

METHYLENE-BIS-THIOCYANATE (-.4)

Occurrence
- Biocide/slime control agent

METHYL METHACRYLATE POLYMER

Occurrence
- NOHS walk-through

METHYL ISOBUTYL KETONE

Occurrence
- NOHS walk-through

Synonym(s)
- 4-methyl-2-pentanone
- Isobutyl methyl ketone
- MIBK, hexone

Description
- Colorless liquid, pleasant odor

Boiling Point: 117°C-118°C

Permissible Exposure Limits in Air
- 100 ppm (410 mg/m^3)
- 50 ppm (200 mg/m^3) TWA NIOSH and ACGIH
- STEL 75 ppm (300 mg/m^3) (skin)

Immediately Dangerous to Life or Health Concentration
- 3,000 ppm (skin)

METHYL MERCAPTAN (2.2)

Occurrence
- Kraft pulping proces emission

Synonym(s)
- Methanethiol

Description
- Colorless gas, unpleasant garlic/skunk odor

Solubility in Water, g/100 g Water at 20°C: 2.4%

Permissible Exposure Limits in Air
- 10 ppm 15 min ceiling (20 mg/m^3)
- 0.5 ppm TWA ACGIH (8-hour) (1 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 400 ppm (785 mg/m^3)

Registry Toxic Chemicals Number
- PB4375000

Route of Entry into Body
- Inhalation

Symptoms
- Narcosis
- Cyanosis

- Convulsions
- Pulmonary irritation
- Respiratory distress
- Headache
- Nausea
- Vomiting

Target Organs
- Respiratory system
- Lungs
- Central nervous system

Protective Equipment Requirements
- Wear goggles - splash proof/dust proof
- Inform person handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selecton (Upper Limit Devices Permitted)
- 100 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 400 ppm
  - Type C supplied-air respirator with full facepiece, helmet, or hood, operated in pressure demand, positive-pressure or continuous flow mode
  - Self-contained breathing apparatus
- Escape
  - Gas mask with organic vapor canister
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid
- If a person breathes in large amounts of methyl mercaptan, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep affected person warm and rest. Get medical attention as soon as possible.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
  - With emphasis on chronic respiratory disease
  - With emphasis on central nervous system
- Blood chemistry
- CBC
- Vision test
- 14 by 17 chest P.A. X-ray
- Pulmonary functions
- Physician examinations
- EKG recommended if employee to wear full-face respirator

Leaks and Spill Procedures
- Restrict persons without protective equipment
- Remove ignition sources
- Ventilate to disperse gasses
- Apply water spray to knockdown vapor
- Knockdown vapor water is toxic and should be contained

Personal Danger Situation Protection
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid breathing vapors

METHYLOLACRYLAMIDE (9.1)

Occurrence
- Coating and adhesive material

Description
- 60% aqueous solution

METHYL SALICYLATE

Occurrence
- NOHS walk-through

Synonym(s)
- Gaultheria oil
- Wintergreen oil
- Betula oil
- Sweet-birch oil

Description
- Yellow to red liquid, odor of wintergreen, slightly soluble in water, combustible, toxic by ingestion

Specific Gravity: 1.180-1.185
Boiling Point: 222.2°C

METHYL TRIMETHOXY SILANE

Occurrence
- NOHS walk-through

MICA (9.1) (10.1)

Occurrence
- Specialty paper for insulation and filtration wall paper and bituminzed cardboard
- Coating and filler

Synonym(s)
- Mucovite
- Amber mica
- Roscoelite

- Lepidolite
- Phlogopite
- Biotite
- Zinnwaldite

Description
- Colorless odorless flakes or sheets with less than 1% quartz, noncombustible. Impurities: lead, barium, antimony, arsenic, selenium, mercury, insoluble in water

Specific Gravity: 2.6-3.2

Permissible Exposure Limits in Air
- 20 mppcf

MINERAL OIL (MIST) (9.1)

Occurrence
- Creping aid
- Foam control agent

Synonym(s)
- Petrolatum liquid
- Mineral oil
- Paraffin oil

Description
- Released as mist with an odor like burned lubricating machine oil, insoluble in water

Boiling Point: 360°C

Permissible Exposure Limits in Air
- 5 mg/m^3 TWA ACGIH
- STEL 10 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- RI17400000

Route of Entry into Body
- Inhalation

Target Organs
- Respiratory system
- Skin

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact

Remove Clothing
- Promptly if nonimpervious and wet

Respirator Selection
- 25 mg/m^3
  - Mist respirator, except single-use
- 50 mg/m^3
  - Mist respirator, except single-use or quarter mask
  - Supplied-air respirator
  - Fume or high-efficiency particulate respirator
  - Self-contained breathing apparatus
- 250 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, operated in pressure demand, positive-pressure or continuous-flow mode

    - Self-contained breathing apparatus with full facepiece
- 2,500
    - Powered air-purifying respirator with high-efficiency filter
    - Supplied-air respirator with full facepiece, operated in pressure demand, positive-pressure or continuous-flow mode

Employee Should Wash
- Promptly when skin is wet

First Aid
- If this chemical contacts the skin, wash with soap.
- If a person breathes in large amounts of mineral oil mist, move the exposed person to fresh air at once.

MONOCHLOROPROPIOVANILLONE (2.2) (3.2) (4.2) (5.2)

Occurrence
- Chlorination and extraction stage effluent in chemical bleaching

MONURON TRICHLOROACETATE (-.4)

Occurrence
- NOHS walk-through (probably herbicide)

Synonym(s)
- 3-(para-chlorophenyl)-1,1-dimethyl- urea

MORPHOLINE

Occurrence
- NOHS walk-through

Synonym(s)
- Diethylenemide oxide
- Tetrahydro-1,4-oxane

Description
- Clear liquid, weak ammonia odor, flammable, miscible in water

Boiling Point: 128°C
Melting Point: -4.8°C
Specific Gravity: 1.002

Permissible Exposure Limits in Air
- 20 ppm (70 mg/m^3) (skin)
- STEL 30 ppm (105 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 8,000 ppm

NAPHTHA

Occurrence
- NOHS walk through

Synonym(s)

- Aliphatic petroleum naphtha
- Exxon vm and p naphtha
- Shell vm and p naphtha
- Drake special vm and p naphtha (66)
- Amsco special naphtholite
- Boron solvent vm and p 2429
- Petroleum ether

Description

- Colorless liquid with an odor like gasoline and kerosene

Boiling Point: 30°C-60°C

Solubility in Water, g/100 g Water at 20°C: 0.04%

Specific Gravity: 0.6

Permissible Exposure Limits in Air (petroleum naphtha)

- 500 ppm (2000 mg/m^3)
- 350 mg/m^3 NIOSH

Immediately Dangerous to Life or Health Concentration

- 10,000 ppm

NAPHTHALENE (4.2)

(5.2)

Occurrence (7.2)

- NOHS walk-through (8.2)
- Final effluent (9.2)

Synonym(s) (-.4)

- White tar
- Napthalen
- Naphthene
- Moth balls
- Camphor tar
- Moth flakes

Description

- Colorless to brown solid with an odor of mothballs, combustible, carcinogen suspect

Boiling Point: 217.96°C

Solubility in Water, g/100 g water at 20°C: 0.003%

Melting Point: 80.2°C

Immediately Dangerous to Life or Health Concentration

- 500 ppm

Specific Gravity: 1.145 (20°C/4°C)

Permissible Concentrations in Water

- 2,300 micrograms/l (freshwater, acute)
- 620 micrograms/l (freshwater, chronic)
- 2,350 micrograms/l (saltwater, acute)

Permissible Exposure Limits in Air

- 10 ppm (50 mg/m^3)
- STEL 15 ppm (75 mg/m^3)

Registry Toxic Chemicals Number

- QJ0525000

NAPHTHALENE SULFONATE

Occurrence
- NOHS walk-through

NAPHTHENIC NEUTRAL OIL

Occurrence
- NOHS walk-through

NATURAL GUM (9.1)

Occurrence
- Adhesive
- Sizing agent

Description
- Water soluble polymer

NICKEL (-.2)

Occurrence
- Final effluent

Description
- Fumes are flammable and toxic

Permissible Concentrations in Water
- 13.4 micrograms/l (human)
- 7.1 micrograms/l (saltwater, 24-hour average)
- 140 micrograms/l (saltwater, ceiling)

Permissible Exposure Limits in Air
- 1.0 mg/m^3 ACGIH (metal)
- 0.015 mg/m^3 10-hour TWA NIOSH

Registry Toxic Chemicals Number
- QR5950000

NICKEL NITRATE HEXAHYDRATE

Occurrence
- NOHS walk-through

Synonym(s)
- Nickel nitric acid
- Nickelous nitrate
- Nickel (II) nitrate hexahydrate

Description
- Green solid, odorless, combustible

Boiling Point: 136.7°C
Solubility in Water, g/100 g water at 20°C: 60%
Melting Point: 55°C
Specific Gravity: 2.065

Permissible Exposure Limits in Air
- 1.0 mg/m^3 (0.08 ppm)
- 015 mg/m^3 NIOSH 10-hour TWA
- 0.1 mg/m^3 (soluble nickel compounds) ACGIH

NITRIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Aqua fortis
- WFNA
- RFNA
- Hydrogen nitrate
- Azotic acid

Description
- Clear to yellow to red fuming liquid, acrid odor, suffocating fumes, miscible in water

Boiling Point: 60°C-121.6°C
Melting Point: -41°C to -52°C
Specific Gravity: 1.504
Permissible Exposure Limits in Air
- 2 ppm (5 mg/m^3) NIOSH 10-hour TWA
- STEL 4 ppm (10 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 100 ppm

NITRIC OXIDE

Occurrence
- NOHS walk-through

Description
- Colorless gas (reacts with oxygen at room temperature to form nitrogen dioxide), slightly soluble in water, noncombustible, highly toxic by inhalation, strong irritant to tissues

Boiling Point: -152°C
Specific Gravity: 1.27 (at boiling point)
Permissible Exposure Limits in Air
- 25 ppm (30 mg/m^3)
- STEL 35 ppm (45 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 100 ppm

NITRILOTRIACETIC ACID (6.1)

Occurrence
- Sequestering agent in dithionite bleaching (mechanical pulps)

Synonym(s)
- NTA

- TGA
- Triglycine
- Triglycollamic acid

Description
- White crystalline powder, may be carcinogenic

Melting Point: 240°C

NITROCELLULOSE (9.1)

Occurrence
- Barrier coating

Synonym(s)
- Cellulose nitrate

Description
- Dry - pulpy, cotton-like, amorphous solid, solution - colorless liquid to semi-solid, soluble in ether-alchol mixtures and acetone, highly flammable

Specific Gravity: 1.66

NITROGEN (-.4)

Occurrence
- NOHS walk-through

Description
- Colorless, odorless, tasteless gas or colorless liquid, noncombustible and nontoxic, slightly soluble in water, asphyxiant

Density (liquid): 1.251 g/l (0°C, 1 atm)
Specific Gravity (gas): 0.96737
(solid): 1.0265
Boiling Point: -195.5°C

N-[a-(1-NITROETHYL)BENZYL]ETHYLENEDIAMINE (9.1)

Occurrence
- Biocide/slime control agent

NITROGEN OXIDES (2.2) (3.2)

Occurrence
- Oil-fired power boilers (particulate)

Description
- Includes several compounds (oxidation states of nitrogen) of which nitrogen dioxide is the most toxic (by inhalation)

Permissible Exposure Limits in Air
- 5 ppm (9 mg/m^3)
- 1 ppm (1.8 mg/m^3) (ceiling) NIOSH
- 3 ppm (6 mg/m^3) TWA ACGIH
- STEL 5 ppm (10 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 50 ppm

O-NITROTOLUENE

Occurrence
- NOHS walk-through

Synonym(s)
- Ortho-nitrotoluene
- ONT
- Ortho-methylnitrobenzene

Description
- Yellow liquid or solid, weak aromatic odor, combustible

Boiling Point: 220.4°C
Solubility in Water, g/100 g water at 20°C: 0.06
Melting Point: -9.3°C
Specific Gravity: 1.1629 (20°C)
Permissible Exposure Limits in Air
- 5 ppm (30 mg/m^3)
- 2 ppm (11 mg/m^3) ACGIH (skin)

Immediately Dangerous to Life or Health Concentration
- 200 ppm

OCTADECYLAMINE

Occurrence
- NOHS walk-through

OCTANOIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Octylic acid
- Octoic acid
- Caprylic acid

Description
- Colorless, oily liquid, slight odor, rancid taste, slightly soluble in water, combustible, low toxicity.

Specific Gravity: 0.9105 (20°C/4°C)
Melting Point: 16°C
Boiling Point: 237.9°C, 147.9°C (30 mm)

OCTYL ALCOHOL (SEC-N-) (9.1)

Occurrence
- Foam control agent

Synonym(s)
- Capryl alcohol
- 2-n-Octanol
- Methyl hexyl carbinol

Description
- Colorless, oily liquid, aromatic odor, slightly soluble in water, combustible, low toxicity

Specific Gravity: 0.825 (15°C)
Boiling Point: 178°C-179°C

OLEIC ACID (-.2)

Occurrence
- Final effluent
- NOHS walk-through

Synonym(s)
- Cis-9-Octadecanoic acid
- Red oil

Description
- Monounsaturated fatty acid, component of tall oil, insoluble in water, combustible and nontoxic. Commercial grade is yellow to red oily liquid, lard-like odor, darkens on exposure to air; purified grade is water-white liquid

Specific Gravity: 0.895 (20°C/4°C) (purified)
Boiling Point: 286°C (100 mm) (purified)
Registry Toxic Chemicals Number
- RG2275000

OLEYL AMINE

Occurrence
- NOHS walk-through

OXALIC ACID (2.1)

(3.1)

Occurrence (4.1)
- Bleaching and deinking (5.1)

Synonym(s) (8.1)
- Oxalic Acid Dihydrate
- Ethanediodic Acid

Description
- Colorless, odorless solid, carcinogen suspect

Boiling Point: 149°C-160°C (sublimes)
Solubility in water, g/100 g water at 20°C: 10%
Melting Point: 187°C (anhydrous)
101.5°C (dihydrate)
Permissible Exposure Limits in Air
- 0.2 ppm (1 mg/m^3)
- STEL 2 mg/m^3 ACGIH

Immediately Dangerous to Life or Health Concentration
- 500 mg/m^3 (97 ppm)

OXYGEN (2.1)

Occurrence (3.1)
- Oxygen-stage chemical bleaching

Description
- Colorless, odorless, diatomic gas (liquid at -183°C)

Specific Gravity: 1.10535 (gas), 1.14 (liquid), air = 1.00

PARACLOX (9.1)

Occurrence
- Biocide/slime control agent

PARAFFIN (9.1)

Occurrence
- Pigment filler/coating

Synonym(s)
- Parraffin wax
- Hard paraffin

Description
- White, translucent, tasteless, odorless solid, mixture of solid aliphatic hydrocarbons

Density: 0.90

Melting Point: 50°C-57°C

Permissible Exposure Limits in Air
- 2.0 mg/m^3 TWA ACGIH
- STEL 6 mg/m^3 ACGIH

Registry Toxic Chemicals Number
RV0350000

Route of Entry into Body
- Inhalation
- Skin contact

Symptoms
- Dermatitis
- Carcinoma

Target Organs
- Skin

Protective Clothing Requirements
- Avoid prolonged skin contact

Medical Surveillance
- General medical history
- Skin examinations

Waste Disposal Method
- Incineration

PENTACHLORPHENOL (-.2) (9.1)

Occurrence
- Final effluent
- Biocide and slime control agent

Synonym(s)
- PCP
- Penchlorol

Description
- White to light brown powder or crystals, slightly soluble in water, highly toxic by ingestion, inhalation, skin absorption

Permissible Concentrations in Water
- 55 micrograms/l (freshwater, acute)
- 3.2 micrograms/l (freshwater, chronic)
- 53 micrograms/l (saltwater, acute)
- 34 micrograms/l (saltwater, chronic)
- 1,010 micrograms/l (human)
- 21 micrograms/l (drinking)

Permissible Exposure Limits in Air
- 0.5 mg/m^3
- STEL 1.5 mg/m^3 (skin)

Immediately Dangerous to Life or Health Concentration
- 150 mg/m^3

Registry Toxic Chemicals Number
- SM6300000

PENTAERYTHRITOL (9.1)

Occurrence
- Rosin and tall oil esters

Synonym(s)
- Tetramethylolmethane
- Auxinutril
- 2,2-bis(hydroxymethyl)-1,3-propanediol
- Hercules P6
- Maxinutril
- Methane tetramethylol
- Tetrakis(hydroxymethyl)methane
- Pentaerythrite

Description
- Odorless, white, crystalline solid, combustible, low toxicity

Boiling Point: 276°C (30 mm)
Solubility in Water: 1 g/18 ml at 20°C
Melting Point: 262°C
Specific Gravity: 1.38

Permissible Exposure Limits in Air
- 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH

Registry Toxic Chemicals Number
- RZ2490000

PENTASODIUM DIETHYLENE-TRIAMINE PENTA-ACETATE

(6.1)

Occurrence
- Sequestering agent in mechanical peroxide bleaching

PERACETIC ACID

(2.1)
(3.1)
(4.1)
(5.1)

Occurrence
- Alternative to peroxide in chemical bleaching

Synonym(s)
- Peroxyacetic acid
- Acetylhydroperoxide

Description
- Colorless liquid, strong odor, soluble in water, strong irritant

Boiling Point: 105°C
Specific Gravity: 1.15 (20°C)

PETROLATUM

(-.4)

Occurrence
- NOHS walk-through (lubricant)

Description
- Colorless to amber, oily, transparent amorphous mass, insoluble in water, combustible and nontoxic

Specific Gravity: 0.815-0.880 (60°C)
Melting Point: 38°C-60°C

PETROLEUM SULFONATE

Occurrence
- NOHS walk-through

PHENOL

(-.2)
(9.1)

Occurrence
- Final effluent
- Phenol-formaldehyde resins

Synonym(s)
- Carbolic Acid
- Mono Hydroxy Benzene
- Phenylihydroxide

Description
- Colorless to pink solid or thick liquid with sweet, tar odor

Solubility in Water, g/100 g water at 20°C: 8.4%
Permissible Concentrations in Water
- 2,560 micrograms/l (freshwater, chronic)
- 10,200 micrograms/l (freshwater, acute)
- 5,800 micrograms/l (salt water)

- 3,500 micrograms/l (human)
- 300 micrograms/l (drinking)

Permissible Exposure Limits in Air
- 5 ppm (19 mg/m^3)
- 20 mg/m^3 TWA (10-hour) NIOSH
- 60 mg/m^3 Ceiling (15-minute) NIOSH
- STEL 10 ppm (38 mg/m^3) (skin)

Immediately Dangerous to Life or Health Concentration
- 100 ppm (384 mg/m^3)

Registry Toxic Chemicals Number
- SJ3325000

PHENOL-FORMALDEHYDE RESIN (9.1)

Occurrence
- Coating

Description
- Gray to black hard, infusible solid, noncombustible and nontoxic

PHENOLPHTHALEIN (9.1)

Occurrence
- Acid-base indicator (contains phthalic acid)

Synonym(s)
- 3,3-Bis(para-hydroxyphenyl)phthalide

Description
- Pale yellow powder, forms almost colorless solution in neutral or acid solution, pink to deep red in presence of alkali, turns colorless in presence of large amounts of alkali.

PHENYL MERCURIC ACETATE (9.1)

Occurrence
- Biocide/slime control agent

Description
- White to cream prisms, slightly soluble in water, highly toxic by ingestion, inhalation and skin absorption

Permissible Exposure Limits in Air
- 0.01 mg/m^3

N-(1-PHENYL-2-NITROPROPYL)PIPERAZINE

Occurrence
- Biocide/slime control agent

PHOSPHORIC ACID

Occurrence
- Filler/coating

Synonym(s)
- White phosphoric acid
- Ortho-phosphoric acid
- 85% phosphoric acid
- Metal phosphoric acid

Description
- Viscous, colorless, odorless liquid, miscible in water, carcinogen suspect

Boiling Point: 260°C
Melting Point: 42.35°C
Specific Gravity: 1.834 (18°C)

Permissible Exposure Limits in Air
- 1 mg/m^3 (2 ppm)
- STEL 3 mg/m^3

Registry Toxic Chemicals Number
- TB6300000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Irritation of eye(s), skin
- Skin burn
- Respiratory distress
- Dermatitis
- Dry throat
- Pulmonary edema
- Pulmonary sensitization
- Wheezing
- Ataxia
- Confusion

Target Organs
- Respiratory system
- Lungs
- Eyes
- Skin

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
Advise:
- Any possibility of eye contact

Work Clothing Should Be Changed Daily
- After work shift if contaminated

Remove Clothing
- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 50 mg/m^3
  - High efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 2,000 mg/m^3
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode with full facepiece, helmet, or hood, operated in continuous flow mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If phosphoric acid gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Physician examination
- Pulmonary functions
- Respiratory history
- 14 by 17 chest P.A. x-ray
- Skin exam
- Periodic exam following exposure
- EKG recommended if employee to wear full-face respirator
- Vision test
- Urinalysis

- Blood chemistry
- CBC
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provided medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Remove ignition sources
- Keep material out of water sources and sewers
- Neutralize spilled material with crushed limestone, soda ash or lime
- Apply water spray to knock down vapors
- Vapor knockdown water is corrosive or toxic and should be contained

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear full protective clothing (fireman's gear inadequate)

Waste Disposal Methods
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

PHOSPHOROUS (9.1)

Occurrence
- Oil-fired power boilers (particulate)

Permissible Exposure Limits in Air
- 0.1 mg/m^3
- STEL 0.3 mg/m^3

PHTHALIC ALKYD

Occurrence
- NOHS walk-through

PHTHALIC ANHYDRIDE

Occurrence
- NOHS walk-through

Synonym(s)
- PAN
- Phthalic acid anhydride

Description
- White solid with a characteristic choking odor, carcinogen suspect, sensitizing agent

Boiling Point: 285°C
Solubility in Water, g/100 g water at 20°C: 0.62%
Melting Point: 131.16°C
Specific Gravity: 1.527 (4°C)
Permissible Exposure Limits in Air
- 2 ppm (12 mg/m^3)
- 1 ppm (6 mg/m^3) ACGIH TWA
- STEL 4 ppm (24 mg/m^3)

Registry Toxic Chemicals Number
- TI3150000

Immediately Dangerous to Life or Health Concentration
- 10,000 ppm

PHTHALOCYANIDE BLUE (9.1)

Occurrence
- Dye

PIMARIC ACID (9.1) (-.2)

Occurrence
- Final effluent (derived from pine gum, used in resins)

Description
- Insoluble in water, combustible, low toxicity

PINE OIL (9.12)

Occurrence
- Foam control agent

Description
- Colorless to light amber liquid, strong piny odor, combustible, low toxicity

Specific Gravity: 0.927-0.940

PIPERONYL BUTOXIDE (-.4)

Occurrence
- Used in insecticides with pyrethrins

Synonym(s)
- Alpha-[2-(2-butoxyethyl)-ethoxy]-4,5-(methylenedioxy)-2-propyl- toluene

Description
- Light brown liquid, mild odor, insoluble in water, combustible, low toxicity

Specific Gravity: 1.06 (25°C)
Boiling Point: 180°C (1 mm)

POLYACROLEIN (9.1)

Occurrence
- Wet-strength/dry-strength polyester resin

POLYACRYLAMIDE (9.1)

Occurrence
- Wet-strength/dry strength agent
- Retention and formation aid

Description
- Complex polymer formed from acrylamide slurry or resin suspension, with acrylic acid or aluminum hydroxide

POLYBUTYLENE (9.1)

Occurrence
- Coating and adhesive material

Synonym(s)
- Polybutene
- Polyisobutylene
- Polyisobutene

Description
- Includes several thermoplastic isotactic polymers of isobutene; all are combustible and nontoxic. Butyl rubber is one such copolymer of isobutylene and isoprene.

POLYCHLORINATED BIPHENYLS (5.2) (7.2) (8.2) (9.2) (10.2)

Occurrence
- Paper recycling in deinking operations (formerly used as dye carrier in production of copy paper)
- Final effluent (includes PCB's 1248 and 1260 from deinking and waste paper processes)

Synonym(s)
- PCB's
- Aroclor 1242
- Aroclor 1254
- Chlorodiphenyls

Description
- Colorless liquid, carcinogen

Specific Gravity: 1.4-1.5
Permissible Exposure Limits in Air (54% chlorine)
- 0.5 mg/m^3
- 1.0 micrograms/m^3 10-hour TWA NIOSH
- STEL 1.0 mg/m^3 ACGIH

Permissible Concentrations in Water
- Preferably zero (0.00079 micrograms/l ceiling) (human)
- 0.030 micrograms/l (saltwater, 24-hour averge)
- 0.014 micrograms/l (freshwater, 24-hour average)

Immediately Dangerous to Life or Health Concentration
- 5 mg/m^3

Registry Toxic Chemicals Number
TQ1350000

Route of Entry into Body
- Inhalation
- Ingestion
- Eye and skin contact
- Skin absorption

Symptoms
- Edema
- Jaundice
- Vomiting
- Anorexia
- Nausea
- Abdominal pains
- Fatigue
- Eye, nose, throat irritation

Target Organs
- Skin
- Eyes
- Liver

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious boots

Remove Clothing
- Promptly if impervious and wet or contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

Respirator Selection
- 5 mg/m^3
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with pesticide canister (chin-style or front- or back-mounted)

Employee Should Wash
- Promptly when skin becomes wet or contaminated

First Aid
- If PCB's gets into the eyes, irrigate immediately
- If there is skin contact, wash with soap immediately
- If a person breathes in large amounts, move the exposed person to fresh air at once and perform artificial respiration

Medical Surveillance
- Medical history
- Evaluation of skin, lung, liver functions
- Possible effects on fetus should be considered

Waste Disposal Methods
- Incinerate wastes containing PCB's at 1648°C with scrubbing to remove any chlorine-containing products

POLY(DIMETHYLDIALLYLAMMONIUM CHLORIDE) (9.1)

Occurrence
- Retention aid

POLY(1,2-DIMETHYL-5-VINYLPYRIDINIUM METHYLSULFATE) (9.1)

Occurrence
- Retention aid

POLYETHYLENE (LOW DENSITY) (9.1)

Occurrence
- Coating
- Wet-strength/dry-strength agent

Specific Gravity: 0.915
Melting Point: 115.5°C

POLYETHYLENE GLYCOL (9.1)

Occurrence
- Paper coating

Synonym(s)
- Carbowax
- Carbowax 1000
- Lutril
- P.E.G. 400

Description
- Colorless, clear, odorless liquid, soluble in water, combustible and nontoxic

Permissible Exposure Limits in Air
- 10 mg/m^3 8-hour TWA ACGIH

POLYETHYLENE GLYCOL DIMETHACRYLATE

Occurrence
- NOHS walk-through

POLYETHYLENE GLYCOL DECANOATE

Occurrence
- NOHS walk-through

POLYETHYLENE GLYCOL DIOLEATE

Occurrence
- NOHS walk-through

POLYETHYLENE GLYCOL TRIDECYL ETHER

Occurrence
- NOHS walk-through

POLYETHYLENEIMINE (9.1)

Occurrence
- Paper adhesive and anchoring agent
- Retention aid
- Paper dewatering agent and wet strength improver

Description
- Synthetic polymer, highly viscous, hygroscopic liquid when anhydrous, soluble in water, combustible

POLY(ETHYLENE OXIDE) (9.1)

Occurrence
- Formation aid

POLYMER WITH CHLOROETHENE, ACETIC ACID ETHERYL ESTER

Occurrence
- NOHS walk-through

POLY(METHYLDIALLYLAMINE) (9.1)

Occurrence
- Wet-strength/dry-strength agent

POLYMETHYLSILOXANE

Occurrence
- NOHS walk-through

POLYPROPYLENE

Occurrence
- NOHS walk-through

Description
- Synthetic crystalline thermoplastic polymer, translucent white solid, combustible and non-toxic

POLYPROPYLENE GLYCOLS

Occurrence
- NOHS walk-through

Synonym(s)
- PPG

Description
- Clear colorless viscous liquid, combustible, soluble in water, various melting and boiling points

Permissible Exposure Limits in Air
- 10 mg/m^3 8-hour TWA ACGIH

POLYSTYRENE (9.1)

Occurrence
- Pigment filler/coating (in polystyrene latex)

POLYVINYL ACETATE (9.1)

Occurrence
- Binder and adhesive agents
- Wet-strength/dry-strength agent

Synonym(s)
- PVAc

Description
- Colorless, odorless, transparent solid, insoluble in water, combustible, nontoxic

Specific Gravity: 1.19 (15°C)

Registry Toxic Chemicals Number
- AK0920000

POLYVINYL ALCOHOL (9.1)

Occurrence
- Adhesive and coating agent
- Sizing agent
- Wet-strength/dry-strength agent

Synonym(s)
- PVA
- PVOH

Description
- White to cream-colored powder, combustible, carcinogen suspect

Specific Gravity: 1.27-1.31

Registry Toxic Chemicals Number
- TR8100000

POLYVINYL CHLORIDE (9.1)

Occurrence
- Binding agent

Description
- Synthetic thermoplastic polymer, white powder or colorless granules, evolves toxic fumes of hydrogen chloride upon heating to decomposition

Melting Point: 148°C (Decomposes)

POLYVINYLIDENE CHLORIDE (9.1)

Occurrence
- Pigment filler/coating
- Insecticide for impregnated multiwall paperbags

Description
- Tasteless, odorless, combustible and nontoxic steroregular thermoplastic polymer

POLYVINYLPYRIDINE (9.1)

Occurrence
- Retention aid
- Antistatic agent

POLYVINYL TRIMETHYLBENZYLAMMONIUM CHLORIDE

Occurrence
- NOHS walk-through

PORTLAND CEMENT (9.1)

Occurrence
- Paper coating/filler

Synonym(s)
- Hydraulic cement
- Cement
- Dicalcium silicate

Description
- Odorless grey powder with less than 1% crystalline silica; also composed of lime, alumina, silica, iron oxide, insoluble in water

Permissible Exposure Limits in Air
- TLV 10 mg/m^3 ACGIH
- STEL 20 mg/m^3 ACGIH

POTASSIUM BIFLUORIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Potassium acid fluoride
- Potassium hydrogen fluoride

Description
- Colorless crystals, decomposes with heat, soluble in water. Highly toxic and corrosive to tissue.

Specific Gravity: 2.37
Melting Point: 238°C
Permissible Exposure Limits in Air
- 2.5 mg/m^3

POTASSIUM CARBONATE

Occurrence
- NOHS walk-through

Synonym(s)
- Potash
- Pearl ash

Description
- White, deliquescent, granular translucent powder, alkaline reaction, soluble in water, noncombustible, strong tissue irritant.

Specific Gravity: 2.428
Melting Point: 891°C
Boiling Point: Decomposes

POTASSIUM CHROMATE (9.1)

Occurrence
- Pigments and inks

Synonym(s)
- Chromate of potash
- Potassium chromate (VI)
- Tarapacaite
- Neutral potassium chromate

Description
- Yellow solid, odorless, known carcinogen and sensitizing agent

Solubility in Water, g/100 g water at 20°C: 39%
Melting Point: 971°C
Specific Gravity: 2.7319
Permissible Exposure Limits in Air
- 0.05 mg/m^3 OSHA

Registry Toxic Chemicals Number
- GB2940000

POTASSIUM DICHROMATE (9.1)

Occurrence
- Pigments

Synonym(s)
- Potassium bichromate
- Red potassium chromate

Description
- Bright, yellowish-red transparent crystals, bitter metallic taste, soluble in water, combustible, toxic by ingestion.

Specific Gravity: 2.676 (25°C)
Melting Point: 396°C

POTASSIUM FERRICYANIDE (9.1)

Occurrence
- Blueprint paper electroplating-sensitive coating

Synonym(s)
- Red prussiate of potash
- Red potassium prussiate

Description
- Bright red lustrous crystals or powder, soluble in water. Decomposes on strong heating to evolve highly toxic fumes, though compound itself is low toxicity.

Specific Gravity: 1.25°C

POTASSIUM FERROCYANIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Yellow prussiate of potash
- Yellow potassium prussiate

Description
- Lemon yellow crystals or powder, mild saline taste, effloresces on exposure to air, soluble in water. When heated to red heat, highly toxic fumes evolve.

Specific Gravity: 1.853 (17°C)
Melting Point: Loses water of crystallization when heated to 70°C
Boiling Point: Decomposes

POTASSIUM HYDROXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Caustic potash
- Lye water
- Potassa
- Potassium hydrate

Description
- White water solution

Boiling Point: 1320°C-1324°C
Solubility in Water, g/100 ml water at 20°C: 111 g
Melting Point: 405°C
Specific Gravity: 2.044
Permissible Exposure Limits in Air
- ACGIH 2 mg/m^3 ceiling

Registry Toxic Chemicals Number
- TT2100000

POTASSIUM IODIDE

Occurrence
- NOHS walk-through

Description
- White crystals, granules, or powder, soluble in water, low toxicity

Specific Gravity: 3.123
Melting Point: 686°C
Boiling Point: 1330°C

POTASSIUM NITRATE

Occurrence
- NOHS walk-through

Synonym(s)
- Niter
- Nitre
- Saltpeter

Description
- Transparent, colorless or white crystalline powder or crystals, slightly hygroscopic, pungent and saline taste, soluble in water, low toxicity. Dangerous fire and explosive risk when heated.

Specific Gravity: 2.1062
Melting Point: 337°C
Boiling Point: 400°C (Decomposes)

POTASSIUM OXIDE

Occurrence
- NOHS walk-through

Description
- Gray crystalline mass, soluble in water, toxic and corrosive to tissue

Specific Gravity: 2.32 (0°C)

POTASSIUM PENTABORATE

Occurrence
- NOHS walk-through

POTASSIUM PERMANGANATE

Occurrence
- NOHS walk-through

Description
- Dark purple crystals, blue metallic sheen, sweetish and astringent taste, odorless, soluble in water, combustible

Specific Gravity: 2.7032

POTASSIUM PERSULFATE (9.1)

Occurrence
- NOHS walk-through (defiberizing of wet-strength paper)

Synonym(s)
- Potassium peroxydisulfate

Description
- White crystals, soluble in water, moderately toxic, strong irritant

Specific Gravity: 2.477
Melting Point: Decomposes below 100°C

POTASSIUM PHOSPHATE

Occurrence
- NOHS walk-through

Synonym(s)
- Postassium phosphate, monobasic
- Potassium phosphate, dibasic

Description
- Colorless to white crystals or white powder, soluble in water

Specific Gravity: (monobasic) 2.338
Melting Point: (monobasic) 253°C

POTASSIUM PHOSPHATE, TRIBASIC (9.1)

Occurrence
- Surfactant

Synonym(s)
- Potassium phosphate, neutral
- Potassium phosphate, normal
- Tripotassium ortho-phosphate
- Potassium phosphate, tertiary
- Tripotassium phophate

Description

- Granular white powder, soluble in water

Specific Gravity: (Anhydrous) 2.564 (17°C)

Melting Point: (Anhydrous) 1340°C

POTASSIUM TITANATE (9.1)

Occurrence

- Pigment and coatings

Description

- White salt, hydrolyzes in water to form strongly alkaline solution

PROPANE (-.4)

Occurrence

- NOHS walk-through

Synonym(s)

- Dimethylmethane
- Propyl hydride

Description

- Colorless, odorless gas, foul smelling (odorant often added), asphyxiant, insoluble in water

Boiling Point: -42.5°C

Melting Point: -187.7°C

Permissible Exposure Limits in Air

- 1000 ppm (1800 mg/m^3)

Immediately Dangerous to Life or Health Concentration

- 20,000 ppm (35,992 mg/m^3)

Registry Toxic Chemicals Number

- TX2275000

Route of Entry into Body

- Inhalation
- Skin or eye contact

Symptoms

- Dizziness
- Paresthesias
- Frostbite
- Salivation
- Headache
- Vomiting

Target Organs

- Central nervous system

Protective Equipment Requirements

- Prevent skin freezing
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing Should Be Changed Daily

- After work shift if contaminated

Remove Clothing

- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 10,000 ppm
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 20,000 ppm
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
  - Type C supplied-air respirator, operated in pressure demand or positive-pressure or in continuous flow mode
- Escape
  - Self-contained breathing apparatus

Firefighting
- Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:
- Promptly when skin becomes contaminated

First Aid
- If propane gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water. If it soaks clothing, immediately remove clothing and flush with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance
- General medical history
- Industrial exposure history
- Physician exam
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions
- Respiratory history
- Skin exam
- Vision test
- Urinalysis

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse gasses
- Stop flow of gas
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- Cool all affected containers with flooding quantities of water
- Use water spray to knock down vapors
- Apply water from as far a distance as possible
- Attempt to stop leak if without hazard
- Keep sparks, flames and other ignition sources away

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Approach fire with caution

Waste Disposal Methods

- Incineration

PROPYL ACETATE

Occurrence

- NOHS walk-through

Synonym(s)

- n-Propyl acetate
- n-Propyl ester

Description

- Colorless liquid, mild, fruity odor

Boiling Point: 101°C-102°C

Permissible Exposure Limits in Air

- 200 ppm (840 mg/m^3)
- STEL 250 ppm (1,050 mg/m^3)

Immediately Dangerous to Life or Health Concentration

- 8000 ppm

PROPYL ALCOHOL

Occurrence

- NOHS walk-through

Synonym(s)

- 1-Propanol
- Ethyl Carbinol

Description

- Colorless liquid with a mild, non-residual alcoholic odor, combustible, miscible in water

Boiling Point: 97.2°C

Melting Point: -121.6°C

Specific Gravity: 0.804 (20°C/4°C)

Permissible Exposure Limits in Air

- 200 ppm (500 mg/m^3)
- STEL 250 ppm (625 mg/m^3) (skin)

Immediately Dangerous to Life or Health Concentration

- 4,000 ppm (9,815 mg/m^3)

Registry Toxic Chemicals Number

- UH8225000

Route of Entry Into Body

- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Irritation of eye(s), nose
- Dry throat
- Drowsiness
- Unconsciousness
- Headache
- Nausea
- Vomiting
- Diarrhea
- Dry dermatitis
- Gastrointestinal pain
- Drowsiness
- Ataxia
- Respiratory distress
- Abdominal cramps

Target Organs
- Skin
- Eyes
- Respiratory system
- Gastrointestinal system

Protective Equipment Requirements
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Prevent repeated or prolonged skin contact
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Wear Eye Protection to Prevent
- Any possibility of eye contact

Work Clothing Should Be Changed Daily
- After work shift if contaminated

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available
- Eyewash

Respirator Selection (Upper Limit Devices Permitted)
- 1000 ppm
    - Chemical cartridge respirator with organic vapor cartridge
- 2000 ppm
    - Supplied-air respirator
    - Self-contained breathing apparatus
- 4000 ppm
    - Gas mask with organic vapor canister, chin-style or front- or back-mounted
    - Supplied-air respirator with full facepiece, helmet, or hood
    - Self-contained breathing apparatus with full facepiece
- Escape
    - Gas mask with organic vapor canister, chin-style or front- or back-mounted
    - Self-contained breathing apparatus

- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Promptly when skin becomes wet

First Aid

- If propyl alcohol gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately wash with soap or mild detergent and water. If it soaks through clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, get medical attention. If medical attention is not immediately available, get the affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Physician examination
- Skin exam
  - With emphasis on liver disease
- Blood chemistry
  - With emphasis on renal and liver functions
  - With emphasis on kidneys
  - With emphasis on chronic respiratory disease
- Pulmonary functions
- 14 x 17 chest P.A. X-ray
- Periodic exam following exposure

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection

- Avoid breathing vapors
- Keep upwind

- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Do not dump unneutralized substance in sewer due to explosivity.
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill.
- Atomize in suitable safe combustion chamber
- For pits, lagoons, pools or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

PROPYLENE GLYCOL METHYL ETHER

Occurrence

- NOHS walk-through

Synonym(s)

- Polypropylene glycol methyl ether

Description

- Colorless liquid, soluble in water, combustible

Permissible Exposure Limits in Air

- 100 ppm

PROPYLENE OXIDE

Occurrence

- NOHS walk-through

Synonym(s)

- 1,2-epoxypropane
- Methyl oxirane

Description

- Colorless liquid with an ether-like odor, carcinogen suspect

Boiling Point: 33.9°C

Solubility in Water, g/100 g water at 20°C: 41.%

Melting Point: -112.2°C

Specific Gravity: 0.8304 (20°C/20°C)

Permissible Exposure Limits in Air

- 100 ppm OSHA
- 20 ppm (50 mg/m^3) ACGIH

PROPYLPARABEN (-.4)

Occurrence

- NOHS walk-through (fungicide)

Synonym(s)

- Propyl para-hydroxybenzoate

Description
- Colorless crystals or powder, slightly soluble in boiling water, low toxicity.

Melting Point: 95°C-98°C

PYRENE (2.2) (10.2)

Occurrence
- Final effluent (dissolving kraft process)
- Component of asphalt fume

Synonym(s)
- Polynuclear aromatic hydrocarbon

Description
- Carcinogen

Permissible Concentrations in Water
- Perferably zero (human) (EPA)

Permissible Exposure Limits in Air
- 0.2 mg/m^3 ACGIH

PYRETHRIN I (9.1) (-.4)

Occurrence
- Treatment of paperbags for shipping cereals
- Insecticide

Description
- Viscous brown resin or solid, insoluble in water

Boiling Point: 150°C
Melting Point: Decomposes
Permissible Exposure Limits in Air
- 4 ppm (5 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 5,000 ppm

PYRETHRIN II (9.1) (-.4)

Occurrence
- Insecticide

Synonym(s)
- Jasmolin
- ENT 7,543
- Pyrethrolone
- Chrysantheum
- Dicarboxylic acid methyl ester

Description
- Viscous brown resin or solid, insoluble in water

Boiling Point: 200°C
Melting Point: Decomposes
Permissible Exposure Limits in Air
- 4 ppm (5 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 5,000 ppm

PYROGALLIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Pyrogallol
- 1,2,3-trihydroxybenzene

Description
- White, lustrous crystals which turn gray on exposure to light, brown on exposure to air (solution), soluble in water. Toxic by ingestion and skin absorption.

Specific Gravity: 1.463
Melting Point: 132.5°C
Boiling Point: 309°C

RICINOLEIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Cis-12-hydroxyoctadec-9-enoic acid
- 12-Hydroxyoleic acid
- Castor oil acid

Description
- Unsaturated fatty acid component of castor oil, colorless to yellow viscous liquid, insoluble in water, combustible, low toxicity.

Specific Gravity: 0.940 (27.4°C/4°C)
Melting Point: 5.5°C
Boiling Point: 226°C (10 mm)

ROSIN (9.1)

Occurrence
- Sizing

Description
- Composed primarily of abietic and pimaric acids. Angular, transparent, amber-colored fragments, insoluble in water, combustible and low toxicity, evolves irritating and suffocating fumes when heated.

Specific Gravity: 1.08
Melting Point: 100°C-150°C

SALICYLIC ACID (9.1)

Occurrence
- NOHS walk-through (probably used with resins)

Synonym(s)
- Ortho-hydroxybenzoic acid

Description
- White powder, acrid taste, gradually discolored in light, slightly soluble in water, moderately toxic by ingestion.

Specific Gravity: 1.443 (20°C/4°C)
Melting Point: 158°C-161°C
Boiling Point: 211°C (20 mm)

SELENIUM (2.2)

Occurrence
- Oil-fired power boilers (particulate)

Permissible Exposure Limits in Air
- 0.2 mg/m^3

Immediately Dangerous to Life or Health Concentration
- 100 mg/m^3

SILICA (AMORPHOUS) (9.1)

Occurrence
- Pigment filler and coating

Synonym(s)
- Diatomite
- Silicon Dioxide
- Diatomaceous Earth
- CAB-O-SIL
- DRI-DIE
- SG-67
- Silikil

Description
- Colorless to grey, odorless particulate, noncombustible, insoluble in water

Boiling Point: 2230°C
Melting Point: 17.0°C
Specific Gravity: 2.2-2.6
Permissible Exposure Limits in Air
- 20 mppcf
- 6 mg/m^3 total dust ACGIH
- 3 mg/m^3 respirable dust

Registry Toxic Chemicals Number
- VV7320000

Route of Entry Into Body
- Inhalation
- Skin or eye contact

Symptoms
- Cough
- Dyspnea
- Respiratory distress
- Pulmonary fibrosis

- Pneumoconiosis
- Pleural thickening
- Silicosis
- Emphysema
- Dry throat

Target Organs

- Respiratory system
- Lungs
- Eyes

Protective Equipment Requirements

- Prevent skin contact
- Wear impervious clothing
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Respirator Selection (Upper Limit Devices Permitted)

- 100 mppcf
  - Dust and mist respirator
- 200 mppcf
  - Dust and mist respirator, except quarter-mask, except single use
  - Fume or high-efficiency particulate respirator
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 1000 mppcf
  - High-efficiency particulate respirator with full facepiece
  - Self-contained breathing apparatus with full facepiece
  - Supplied-air respirator with full facepiece, helmet or hood
- 10,000 mppcf
  - Powered air-purifying respirator with high-efficiency particulate filter
  - Type C supplied-air respirator with or without full facepiece, helmet, or hood operated in pressure demand, positive-pressure or continuous flow mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

First Aid

- If silica gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Physician examination
  - With emphasis on chronic respiratory disease

    - With emphasis on cardiovascular disease
- 14 by 17 chest P.A. X-ray
- UICC chest X-ray
- TB tine test
- Pulmonary functions
- Vision test
- EKG recommended if employee to wear full-face respirator
- Skin exam

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse dust
- Keep material out of water sources and sewers

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing dust
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Collect solid substance in most safe way for reclamation and place in secured sanitary landfill

SILICA (FIBROUS) (10.1)

Occurrence
- Component of building paper

Synonym(s)
- Min-u-sil
- Silica anhydride
- Fiberglass
- Glass fibers

Description
- Molten glass extruded through fine orfices to produce fibrous structures, noncombustible, insoluble in water

Boiling Point: 2230°C

Melting Point: 815°C (softening point)

Permissible Exposure Limits in Air
- 3 fibers/cc air ceiling NIOSH
- Fiber size 3.5 micrometers 10-hour TWA
- Length - 3 x fiber width
- 10 mg/m^3 TWA ACGIH

SILICIC ACID (9.1)

Occurrence
- Dyes

Synonym(s)
- Hydrated silica

Description
- Jelly-like precipitate obtained upon acidification of sodium silicate solution, becomes amorphous silica when dry

SILICONE (9.1)

Occurrence
- Foam control agent
- Creping aid (oil)

Description
- Liquid or semisolid siloxane polymer, nontoxic

SILVER NITRATE

Occurrence
- NOHS walk-through

Synonym(s)
- Argerol
- Lunar caustic
- Nitric acid, silver (1+) salt
- Silbernitrat

Description
- Colorless and odorless solid which may become gray on storage, carcinogen suspect, caustic and irritating to skin and mucous membranes, may be fatal if swallowed

Boiling Point: 440°C (Decomposes)
Solubility in Water: 1 g in 0.4 ml at 25°C
Melting Point: 212°C
Specific Gravity: 4.328
Permissible Exposure Limits in Air
- 0.01 mg/m^3 (0.001 ppm)

Registry Toxic Chemicals Number
- VW4725000

SILVER OXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Argentous oxide

Description
- Dark brown or black odorless powder, metallic taste, slightly soluble in water.

Specific Gravity: 7.14 (16°C)
Melting Point: 300°C (Decomposes)

SODIUM ABIETATE (9.1)

Occurrence
- Coating

Synonym(s)
- Rosin soap
- Sodium resinate

Description
- White powder, soluble in water, combustible

SODIUM ALUMINATE (9.1)

Occurrence
- Sizing agent

Description
- White powder, soluble in water; toxic, strong tissue irritant

Melting Point: 1800°C

Registry Toxic Chemicals Number
- BD1600000

SODIUM ALUMINOSILICATE (9.1)

Occurrence
- Pigment filler/coating

Synonym(s)
- Sodium silicoaluminate

Description
- Fine, white, amorphous powder or beads, odorless, tasteless, insoluble in water, noncombustible, low toxicity

SODIUM BICARBONATE

Occurrence
- NOHS walk-through

Synonym(s)
- Baking soda
- Sodium acid carbonate

Description
- White powder or crystalline lumps, cooling and slightly alkaline taste, soluble in water, noncombustible, low toxicity

Specific Gravity: 2.159

SODIUM BISULFATE

Occurrence
- NOHS walk-through

Synonym(s)
- Sodium acid sulfate
- Niter cake
- Sodium hydrogen sulfate

Description
- Colorless crystals or white, fused lumps, soluble in water, noncombustible, strong tissue irritant

Specific Gravity: (crystals) 2.435 (13°C)
(lumps) 2.103 (13°C)

Melting Point: (crystals) greater than 315°C
(lumps) 58.5°C

SODIUM BISULFITE

(6.1)
(-.1)

Occurrence
- Reductive bleaching for mechanical pulps
- Antichlor (removes excess chlorine from bleached pulp)

Synonym(s)
- Sodium acid sulfite
- Sodium hydrogen sulfite

Description
- White crystals or crystalline powder; slightly sulfurous odor, noncombustible, soluble in water

Melting Point: Decomposes
Specific Gravity: 1.48
Permissible Exposure Limits in Air
- 5 mg/m^3 (skin)

SODIUM BORATE

(2.1)
(3.1)
(4.1)
(5.1)
(9.1)

Occurrence
- Adhesive
- Bleach

Synonym(s)
- Sodium Tetraborate
- Sodium Pyroborate
- Borax

Physcial Description
- White, odorless crystals or powder, soluble in water, noncombustible

Melting Point: 75°C
Specific Gravity: 1.73 (20°C/4°C)
Permissible Exposure Limits in Air
- 5 mg/m^3

Registry Toxic Chemicals Number
- VZ2275000

Route of Entry into Body
- Inhalation

Protective Equipment Requirements
- Avoid inhalation

SODIUM BOROHYDRIDE

(6.1)

Occurrence
- Reductive mechanical bleaching

Synonym(s)
- Sodium tetrahydroborate

Description
- White, crystalline powder, reacts with hot water to produce hydrogen, flammable

Specific Gravity: 1.07
Melting Point: 36°C-37°C

SODIUM CARBONATE (2.13)

(4.1)

Occurrence (5.1)
- Deinking (6.1)
- NSSC, chemi-mechanical and sodium-base sulfite pulping (8.1)
- Recovered in kraft pulping as make-up chemical (9.1)
- Paper coating

Synonym(s)
- Soda ash
- Sodium carbonate, anhydrous

Description
- Grayish-white powder or lumps, noncombustible and nontoxic

Specific Gravity: 2.53
Melting Point: 851°C
Solubility in Water: 2.2 parts of water at 35°C
Registry Toxic Chemicals Number
- VZ4050000

Route of Entry into Body
- Ingestion
- Skin or eye contact

Symptoms
- Skin and eye irritation
- Necrosis (from concentrated solutions)
- Gastrointestinal tract collapse
- Vomiting
- Diarrhea
- Circulatory collapse

Protective Equipment Requirements
- Avoid skin contact

Wear Eye Protection to Prevent
- Reasonable probability of eye contact

SODIUM (CARBOXYMETHYLCELLULOSE) (9.1)

Occurrence
- Wet-strength/dry-strength agent

Synonym(s)
- Sodium cellulose glycolate

Decription
- White granules

SODIUM CHLORATE (2.1)

(3.1)

Occurrence (4.1)
- Chlorine dioxide perparation (5.1)

Synonym(s)
- Chloric acid, sodium salt

Description
- Colorless, odorless crystals or white granules, saline taste, combustible

Specific Gravity: 2.490
Melting Point: 255°C
Solubility in Water: 100% in 1 ml of water
Boiling Point: Decomposes

SODIUM CHLORIDE (2.13)

(3.1)

Occurrence (4.1)
- Chlorine dioxide preparation (5.1)
- Kraft recovery furnace (combustion product-smelt) (6.1)
- Controlling electrical properties of xerographic paper
- Mordanting of dyes

Synonym(s)
- Common salt
- Rock salt
- Halite
- Table salt

Description
- Colorless, transparent crystals or white crystalline powder, noncombustible, low toxicity

Melting Point: 801°C
Specific Gravity: 2.165
Solubility in Water: 1 g/2.8 ml of water at 25°C
Registry Toxic Chemicals Number
- VZ4725000

SODIUM CHLORITE (2.1)

(3.1)

Occurrence (4.1)
- Chemical bleaching and germicide (5.1)

Description (9.1)
- White crystals or crystalline powder, slightly hygroscopic, soluble in water, combustible, skin irritant

Melting Point: 180°C-200°C
Solubility in Water: 39 g/100 g solution at 17°C; 46 g at 30°C;
53 g at 45°C; 55 g at 60°C

SODIUM CHROMATE (IV) (-.4)

Occurrence
- Used to protect iron against corrosion and rust

Synonym(s)
- Neutral sodium chromate

Description
- Yellow deliquescent crystals (tetrahydrate), soluble in water

Melting Point: (decahydrate) 20°C

SODIUM CITRATE

Occurrence
- NOHS walk-through

Synonym(s)
- Trisodium citrate

Description
- White crystals or granular powder, pleasant acid taste, odorless, soluble in water, combustible and nontoxic.

Melting Point: 150°C
Boiling Point: Decomposes when heated to red heat

SODIUM DICHROMATE (9.1)

Occurrence
- NOHS walk-through (pigments)

Synonym(s)
- Dichromic acid, disodium salt
- Chromic acid, disodium salt
- Bichromate of soda
- Chromium sodium oxide
- Disodium dichromate
- Sodium chromate
- Sodium bichromate
- Sodium dichromate (VI)

Description
- Red to orange solid, odorless, known carcinogen

Boiling Point: 400°C (Decomposes)
Solubility in Water, g/100 g water at 20°C: 236%
Melting Point: 357°C
Specific Gravity: 2.52 (13°C)
Permissible Exposure Limits in Air
- 0.5 mg/m^3 OSHA and ACGIH

SODIUM DIMETHYLDITHIOCARBAMATE (9.1)

Occurrence
- Biocide

Description
- Amber to light green solution (40%), moderately toxic

Specific Gravity: 1.17-1.20 (25°C/25°C)

SODIUM DITHIONITE (6.1)

Occurrence
- Reductive bleaching for mechanical pulps

Synonym(s)
- Sodium hydrosulfite
- Dithionous acid, disodium salt

Description
- Light, lemon-colored solid in powder or flake form, partially soluble in water

Melting Point: 55°C (Decomposes)

SODIUM DODECYLBENZENESULFONATE (9.1)

Occurrence
- Anionic detergent

Synonym(s)
- Dodecylbenzenesulfonic acid

Description
- White to light yellow flakes, granules or powder, combustible

SODIUM EDETATE (6.1)

Occurrence
- Sequestering agent in reductive mechanical bleaching

Synonym(s)
- EDTA
- Tetrasodium EDTA
- Tetrasodium ethylene diaminetetraacetate
- Ethylenediaminetetraacetic acid, tetrasodium salt

Description
- White powder

Solubility in Water: 103 g/100 ml at 25°C

SODIUM FLUORIDE

Occurrence
- NOHS walk-through

Synonym(s)
- FDA 0101
- T-Fluoride
- Flordine
- Flursol
- Karidium
- Luride
- Fluoride dust

Description
- Colorless or blue solid, odorless, carcinogen suspect

Boiling Point: 1695°C
Solubility in Water, g/100 g water at 20°C: 4.2%
Melting Point: 988°C
Specific Gravity: 2.558 (41°C)
Permissible Exposure Limits in Air
- 2.5 mg/m^3 NIOSH

SODIUM FORMATE

Occurrence
- NOHS walk-through

Description
- White, slightly hygroscopic, crystalline powder, slight odor of formic acid, soluble in water.

Specific Gravity: 1.919
Melting Point: 253°C

SODIUM GLUCONATE

Occurrence
- NOHS walk-through

Description
- White to yellowish crystalline powder, soluble in water, low toxicity (derived from glucose by fermentation)

SODIUM HEXAMETAPHOSPHATE (9.1)

Occurrence
- Dispersion of clays and pigments

Synonym(s)
- "Calgon" (a sodium phosphate glass)

Description
- As powder, agglomerated particles, or broken glassy plates, completely soluble in water in all proportions

SODIUM HYDROXIDE (2.1) (3.1) (4.1) (5.1) (6.1) (8.1) (9.1)

Occurrence
- Deinking
- Sulfite, kraft, soda, NSSC and chemi-mechanical pulping
- Alkali extraction during chemical bleaching and pH control
- Oxidative bleaching with hydrogen peroxide (mechanical pulp)
- Chlorine dioxide manufacture
- Paper coating

Synonym(s)
- Caustic Soda
- Soda Lye
- Lye

Description
- White, solid, odorless, noncombustible

Boiling Point: 1390°C
Solubility in water, g/100 g water at 20°C: 50%
Melting Point: 310°C
Permissible Exposure Limits in Air
- 2 mg/m^3 NIOSH (15 minutes)

Immediately Dangerous to Life or Health Concentration
- 200 mg/m^3 (122 ppm)

Registry Toxic Chemicals Number
- WB4900000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or Eye Contact

Symptoms
- Irritation of eyes, nose
- Severe burn
- Mouth burn
- Respiratory distress
- Pneumonitis
- Keratitis
- Severe pain, dry throat

Target Organs
- Eyes
- Respiratory system
- Skin
- Lungs

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing should be Changed Daily
- After work shift if contaminated

Remove Clothing
- Promptly if it is non-impervious and becomes contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 100 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- 200 mg/m^3
  - Powered air-purifying respiratory with full face-piece with high-efficiency particulate filter
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode or with full facepiece, helmet or hood, operated in continuous flow mode
- Escape
  - Dust and mist respirator (except single-use) with full face-piece
  - Self-contained breathing apparatus

- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Immediately when skin becomes contaminated

First Aid

- If sodium hydroxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical
- If this chemical gets on skin, immediately flush skin with water. If it soaks through clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If the chemical has been swallowed, and the person is conscious, immediately give him large quantitites of water to dilute the chemical. Do not attempt to make the exposed person vomit. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Physician examination with emphasis on chronic respiratory disease
- Skin exam
- Vision test
- Eye disease
- Pulmonary functions
- 14 x 17 chest P.A. X-ray
- Pre-placement and annual exams
- X-ray, when repeated pulmonary results or other respiratory tests indicated

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/dust
- Keep material out of water sources and sewers

Personal Danger Situation Protection

- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Do not handle broken packages without protective equipment
- Wear full protective clothing (fireman's gear inadequate)

Waste Disposal Methods

- Place in sealed containers in secured sanitary landfill
- Dilute with water and neutralize with hydrochloric acid
- For pits, lagoons, pools, or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

SODIUM HYPOCHLORITE

(2.1)
(3.1)
(4.1)
(5.1)

Occurrence
- Chemical bleaching and as oxidizer and germicide

Synonym(s)
- Hydrochlorous acid, sodium salt
- Antiformin
- B-K Liquid
- Carrel-Dakin Solution
- Hyclorite
- Milton
- Chlorox

Description
- Pale greenish color, disagreeable odor, usually solution, soluble in cold water

Boiling Point: Decomposes
Melting Point: 18°C

Permissible Exposure Limits in Air
- 1 ppm NIOSH

Registry Toxic Chemicals Number
- NH3486300

Route of Entry into Body
- Inhalation
- Ingestion

Symptoms
- Irritation of mucous membrane
- Gastrointestinal irritability
- Laryngeal edema
- Pulmonary irritation
- Pulmonary edema
- Dermatitis
- Skin irritation
- Respiratory distress
- Dry throat

Target Organs
- Gastrointestinal system
- Lungs
- Respiratory system
- Skin

Protective Equipment Requirements
Advise:
- Wear impervious clothing
- Wear gloves
- Wear faceshield (8 inch minimum)
- Prevent repeated or prolonged skin contact
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing should be Changed Daily
Advise:
- Leaving clothing and equipment for decontamination and disposal

Remove Clothing

Advise:

- Promptly if it is non-impervious and contaminated

Wear Eye Protection to Prevent

Advise:

- Any possibility of eye contact

The Following Equipment should be Available

- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)

Advise:

  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode
  - Type C supplied-air respirator with full facepiece, operated in pressure-demand, positive pressure or continuous flow mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:

  - Promptly when skin becomes contaminated and at the end of each work shift

First Aid

- If sodium hypochlorite gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical
- If this chemical gets on skin, immediately wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove the clothing and wash the skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, and the person is conscious, immediately give him large quantitites of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not attempt to make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance

Advise:

- General medical history
- EKG recommended if employee to wear full-face respirator
- Industrial exposure history
- Physician examination
- Pulmonary functions
- 14 x 17 chest P.A. X-ray
  - With emphasis on chronic respiratory disease
- Skin exam
- Urinalysis

Leaks and Spill Procedures

Advise:

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/dust
- If liquid, use paper towels to absorb small quantities
- To evaporate, use fume hood
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- Apply water spray to knock down vapors
- Vapor knockdown water is corrosive or toxic and should be contained

Personnel danger situation protection

- Avoid bodily contact with material
- Wear full protective clothing (fireman's gear inadequate)
- Wear self-contained breathing apparatus
- Do not handle broken packages without protective equipment
- Wear boots, protective gloves and gas-tight goggles.
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Avoid breathing vapors

Waste Disposal Methods

Advise:

- Collect solid substance in most safe way for reclamation
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- For pits, lagoons, pools, or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

SODIUM LAURYL SULFATE

Occurrence

- NOHS walk-through

Description

- Small white or light yellow crystals, slight characteristic odor, soluble in water

SODIUM LIGNOSULFONATE (9.1)

Occurrence

- Dispersant

SODIUM METASILICATE (ANHYDROUS) (8.1)

Occurrence

- Deinking

Description

- Dustless white granules, soluble in water, nontoxic and noncombustible

Melting Point: 1089°C

SODIUM MYRISTYLSULFATE (9.1)

Occurrence
- Anionic detergent

SODIUM NITRATE

Occurrence
- NOHS walk-through

Synonym(s)
- Nitratine
- Soda niter
- Chile saltpeter
- Nitric acid, sodium salt
- Cubic niter

Description
- Colorless, transparent crystals or white powder, toxic by ingestion

Boiling Point: 380°C (Decomposes)
Solubility in Water, g/100 g water at 20°C: 81.5
Melting Point: 308°C
Specific Gravity: 2.267

SODIUM PENTACHLOROPHENATE (9.1)

Occurrence
- Biocide

Description
- White or tan powder, soluble in water, toxic by ingestion, inhalation, skin irritant

SODIUM PEROXIDE (2.1) (3.1) (4.1) (5.1) (6.1)

Occurrence
- Chemical and mechanical bleaching (alternative to hydrogen peroxide)

Synonym(s)
- Sodium dioxide
- Sodium superoxide
- Disodium dioxide
- Disodium peroxide

Description
- Yellowish-white powder (turns yellow when heated), absorbs water and carbon dioxide from air, soluble in cold water, toxic and irritating

Specific Gravity: 2.805
Melting Point: 460°C
Boiling Point: 657°C (Decomposes)

SODIUM PETROLEUM SULFONATE

Occurrence
- NOHS walk-through

SODIUM ORTHO-PHENYLPHENATE (9.1)

Occurrence
- Biocide/slime control agent

Synonym(s)
- Sodium ortho-phenylphenolate

Description
- White flakes, soluble in water, toxic

SODIUM PHOSPHATE, DIBASIC (9.1)

Occurrence
- Flame retardant

Synonym(s)
- DSP
- Disodium phosphate
- Sodium orthophosphate
- Disodium hydrogen phosphate

Description
- Colorless, translucent crystals or white powder, saline taste, soluble in water, low toxicty, nonflammable, hygroscopic.

Specific Gravity: (dihydrate) 2.066 (15°C)
(heptahydrate) 1.679
(dodecahydrate) 1.5235

Melting Point: (dihydrate) 92.5
(heptahydrate) 48°C
(dodecahydrate) 35°C

SODIUM PHOSPHATE, TRIBASIC (9.1)

Occurrence
- Pitch control agent

Synonym(s)
- TSP
- Trisodium orthophosphate
- Trisodium phosphate
- Tertiary sodium phosphate
- Sodium orthophosphate, tertiary

Description
- Colorless crystals, soluble in water, nonflammable.

Specific Gravity: 1.62 (20°C)
Melting Point: 75°C

SODIUM PHOSPHONATE

Occurrence
- NOHS walk-through

SODIUM PHTHALATE

Occurrence
- NOHS walk-through

SODIUM POLYACRYLATE (9.1)

Occurrence
- Dipersant

SODIUM PYROPHOSPHATE (8.1)

Occurrence
- Deinking newsprint

Synonym(s)
- Tetrasodium pyrophosphate
- TSPP

Description
- Colorless, transparent crystals or white powder, soluble in water

Specific Gravity: 2.45

Melting Point: 880°C

Permissible Exposure Limit in Air
- 5 mg/m^3

Registry Toxic Chemicals Number
- UX7350000

SODIUM SESQUICARBONATE (9.1)

Occurrence
- Detergent emulsion

Description
- White, needle-shaped crystals, soluble in water, noncombustible, tissue irritant.

Specific Gravity: 2.112

Melting Point: Decomposes

SODIUM SILICATE (6.1) (7.1) (8.1) (9.1)

Occurrence
- Sizing agent (also used in deinking)
- Stabilizer for mechanical peroxide bleaching
- Adhesive for paperboard containers

Description
- Lumps of greenish glass soluble in steam under pressure or variously soluble white powders or cloudy to clear liquids of various viscosities, noncombustible and nontoxic

SODIUM SULFATE (2.13)

Occurrence
- Make-up chemical for white liquor in kraft pulping (from recovery furnace)

Synonym(s)
- Salt cake

Description
- White crystals or powder (anhydride), soluble in water, nontoxic and noncombustible

Specifc Gravity: 2.671
Melting Point: 888°C
Registry Toxic Chemicals Number
- WE1650000

SODIUM SULFIDE (2.1)

Occurrence
- Kraft pulping chemical

Synonym(s)
- Sodium monosulfide
- Sodium bisulfide
- Sodium hydrogen sulfide

Description
- Yellow or brick red lumps, flakes or deliquescent crystals, soluble in water, combustible, strong irritant

Specific Gravity: 1.856 (14°C)
1.427 (16°C) (nonohydrate)
Melting Point: 1180°C
920°C (Decomposes) (nonohydrate)
Registry Toxic Chemicals Number
- WE1905000

SODIUM SULFITE (6.1)

Occurrence
- Chemi-mechanical pulping chemical

Synonym(s)
- Sulfurous acid, sodium salt

Description
- White crystals or powder (anhydride), saline or sulfurous taste

Specific Gravity: 2.633
1.539 (heptahydrate)
Melting Point: 150°C (Decomposes) (heptahydrate)

Registry Toxic Chemicals Number
- WT3560000

SODIUM SULFOSUCCINATE

Occurrence
- NOHS walk-through

SODIUM THIOSULFATE (-.1) (9.1)

Occurrence
- Pitch control agent (removes chlorine in bleaching and papermaking)
- Antichlor (removes chlorine from bleached pulp)

Synonym(s)
- Sodium subsulfite, hypo
- Sodium hyposulfite

Description
- White, translucent crystals or powder (pentahydrate), cooling taste with bitter after-taste, soluble in water

Specific Gravity: 1.729 (17°C)
Melting Point: 48°C
Boiling Point: Decomposes

SODIUM 2,4,5-TRICHLOROPHENATE (9.1)

Occurrence
- Biocide

Description
- Buff to light brown flakes, soluble in water

SODIUM 2,4,6-TRICHLOROPHENATE (9.1)

Occurrence
- Biocide

SODIUM TRIPOLYPHOSPHATE (6.1)

Occurrence
- Sequestering agent in dithionite belaching (mechanical pulps)

Synonym(s)
- Triphosphoric acid, sodium salt
- Pentasodium triphosphate
- Sodium triphosphate
- STPP
- Tripolyphosphate

Description
- White granular powder, low toxicity

Boiling Point: Decomposes
Solubility in Water: 20 g/100 ml of water at 25°C
Melting Point: (anhydrous salt) 6.22°C

SODIUM XYLENESULFONATE (9.1)

Occurrence
- Used in detergents

Synonym(s)
- Dimethylbenzenesulfonic acid, sodium salt

SORBITAN FATTY ACID ESTERS

Occurrence
- NOHS walk-through

Synonym(s)
- Sorbitan monolaurate
- Sorbitan monooleate
- Sorbitan monostearate
- Sorbitan monopalmitate
- Sorbitan tristearate

Description
- Amber liquid (monolaurate and monooleate), or cream colored waxy solids with slight odor and bland taste, all are insoluble in water and combustible

Specific Gravity: 1.0 (25°C)
Melting Point: (solids) 54°C

SORBITAN MONOSTEARATE

Occurrence
- NOHS walk-through

SORBITOL

Occurrence
- NOHS walk-through

Synonym(s)
- D-sorbite
- D-sorbitol
- Hexahydric alcohol

Description
- White, odorless, crystalline powder, hygroscopic, faintly sweet taste, soluble in water

Specific Gravity: 1.47 (-5°C)
Melting Point: 93°C-97.5°C

SORBITOL MONOSTEARATE

Occurrence
- NOHS walk-through

SOYBEAN OIL (EPOXIDIZED) (9.1)

Occurrence
- Plasticizer

Synonym(s)
- Soya bean oil
- Soy oil

Description
- Pale yellow, fixed drying oil, combustible, nontoxic

Specific Gravity: 0.924-0.929
Melting Point: 22°C-31°C

STANNOUS OXIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Tin oxide
- Tin protoxide

Description
- Brownish-black powder, unstable in air, insoluble in water, low toxicity

Specific Gravity: 6.3
Melting Point: 1080°C

STARCH (9.1)

Occurrence
- Binding and adhesive agent
- Wet- and dry-strength agent
- Drainage and retention aid
- Sizing agent

Description
- A carbohydrate polymer, white, amorphous, tasteless powder or granules, forms gel in hot water

STEARIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- n-Octadecanoic Acid

Description
- Colorless wax-like solid, insoluble in water, nontoxic

Specific Gravity: 0.8390 (80°C/4°C)
Melting Point: 69.6°C
Boiling Point: 361.1°C

STEARIC ANHYDRIDE (9.1)

Occurrence
- Sizing agent

STEARYL ALCOHOL

Occurrence
- NOHS walk-through

Synonym(s)
- 1-Octadecanol
- Octadecyl alcohol

Description
- Unctuous white flakes or granules with faint odor, bland taste, insoluble in water, combustible and nontoxic

Specific Gravity: 0.8124 (59°C/4°C)
Melting Point: 59°C
Boiling Point: 210.5°C (15 mm)

STILBENE (9.1)

Occurrence
- Stilbene dye (fluorescent brightening agent)

Description
- CI numbers of dye range from 40000 to 40999. Insoluble in water, combustible.

Specific Gravity: 0.9707
Melting Point: 124°C-125°C
Boiling Point: 306°C-307°C

STODDARD SOLVENT (-.4)

Occurrence
- Solvent

Synonym(s)
- Dry cleaning safety solvent
- Mineral spirits

Description
- Colorless liquid (petroleum distillate) with kerosene like odor, insoluble in water

Boiling Point: 150°C-200°C

Permissible Exposure Limits in Air
- 500 ppm (2950 mg/m^3)
- 350 mg/m^3 TWA NIOSH, 18,00 mg/m^3 15-minute ceiling

- 100 ppm (525 mg/m^3) ACGIH
- STEL 200 (1,050 mg/m^3) ACGIH

Registry Toxic Chemicals Number
- WJ8925000

STYRENE (9.1)

Occurrence
- Resins and coatings (i.e., styrene-butadiene, styrene-allyl alcohol, styrene-maleic anhydride copolymers) for binding, sizing and strength

Synonym(s)
- Phenylethylene
- Phenylethyiene
- Vinylbenzene
- Cinnamene
- Styrene Monomer

Description
- Monomer is colorless liquid, sweet aromatic odor, sharp odor at high temperatures, carcinogen suspect

Boiling Point: 145.2°C
Solubility in Water, g/100 g water at 20°C: 0.03%
Melting Point: -30.6°C
Specific Gravity: 0.90 (25°C/25°C)
Permissible Exposure Limits in Air
- 100 ppm 8-hour TWA NIOSH and OSHA (420 mg/m^3)
- 200 ppm ceiling
- 600 ppm 5-minute peak
- 50 ppm ACGIH (215 mg/m^3)
- STEL 100 ppm (425 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 5,000 ppm

Registry Toxic Chemicals Number
- WL3675000

SULFAMIC ACID (2.1) (3.1) (4.1) (5.1)

Occurrence
- Used in chemical bleaching for pH control

Description
- White crystalline solid, non-volatile, non-hygroscopic, soluble in water, combustible

Specific Gravity: 2.1
Melting Point: 205°C

SULFONATED NAPHTHALENE FORMALDEHYDE (9.1)

Occurrence
- Pitch control agent

SULFONATED OIL

(9.1)
(8.1)

Occurrence
- Lubricant
- Foam control agent
- Deinking

Description
- Vegetable or animal oil treated with sulfuric acid; excess acid is washed out and oil is neutralized with small amount of ammonia or caustic soda

SULFUR

(4.1)
(5.1)
(6.1)

Occurrence
- Preparation of sulfite, chemi-mechanical and NSSC pulping liquors (burned to obtain sulfur dioxide)

Description
- Alpha-sulfur: rhombic, octahedral, yellow crystals, transition to beta form at 94.5°C
- Beta-sulfur: monoclinic, prismatic, pale yellow crystals which slowly change to alpha-form below 94.5°C. Both forms are insoluble in water, combustible and nontoxic.

Specific Gravity: (alpha) 2.06
(beta) 1.96
Melting Point: (alpha) 112.8°C
(beta) 119°C
Boiling Point: (beta) 444.6°C

SULFUR DIOXIDE

(2.12)
(3.1)
(4.12)
(5.1)
(6.1)

Occurrence
- Major kraft and sulfite gaseous emission
- Sulfite and NSSC pulping
- Chlorine dioxide preparation
- Mechanical bleaching

Synonym(s)
- Sulfurous Acid Anhydride
- Sulfurous Oxide

Description
- Colorless liquid or gas with a characteristic pungent odor, can be liquid at 10°C, noncombustible, solution known as sulfurous acid

Boiling Point: -10°C
Solubility in water, g/100 g water at 20°C: 10%
Melting Point: -75.5°C

Permissible Exposure Limits in Air
- 5 ppm (13 mg/m^3)
- 0.5 ppm TWA (1.3 mg/m^3) NIOSH
- 2 ppm ACGIH (5 mg/m^3) TWA
- STEL 5 ppm (10 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 100 ppm

Registry Toxic Chemicals Number
- WS4550000

Route of Entry into Body
- Inhalation
- Skin or eye contact

Symptoms
- Irritation of eyes, nose
- Lacrimation
- Cough
- Irritation of mucous membranes
- Pulmonary edema
- Severe respiratory distress
- Constriction

Target Organs
- Respiratory system
- Skin
- Eyes
- Lungs

Protective Equipment Requirements
- Prevent skin freezing
- Wear impervious clothing
- Wear gloves
- Wear faceshield (8 inch minimum)

Work Clothing should be Changed Daily
- If there is any possibility that clothing may be contaminated

Remove Clothing
- Immediately if it becomes wet

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 20 ppm
  - Chemical cartridge respirator
  - Supplied-air respirator
  - Self-contained breathing apparatus with full facepiece when eye or facial irritation present
- 100 ppm
  - Chemical cartridge respirator with full facepiece
  - Gas mask with organic vapor cartridge, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid

- If sulfur dioxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical
- If this chemical gets on skin, immediately flush skin with water. If it soaks through clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance

- General medical history
- Industrial exposure history
- Physician examination
- Vision test
- Eye disease check
- Pulmonary functions
- Respiratory history
- 14 by 17 chest P.A. X-ray
- Skin exam
- Pre-placement and annual exams

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Stop flow of gas
- If in cylinder, remove to safe place in open air for repair or to allow cylinder to empty
- If liquid, allow to evaporate
- Use water spray to knock down vapors
- Neutralize spilled material with crushed limestone, soda ash or lime

Personal Danger Situation Protection

- Keep upwind
- Wear full protective clothing (fireman's gear inadequate)
- Avoid bodily contact with material
- Wear self-contained breathing apparatus
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Method

- Pass into soda ash solution, then add calcium hypochlorite, neutralize and flush to sewer with water.

SULFURIC ACID (2.1)

(3.1)

Occurrence (4.12)

- Formed during sulfite pulping (5.1)
- Chlorine dioxide preparation (6.1)
- Purification of tall oil (9.1)
- Sizing agent
- pH control in mechanical pulp bleaching

Synonym(s)
- BOV
- Dipping Acid
- Hydrogen sulfate

Description
- Colorless to dark brown, oily liquid, odorless, miscible with water, noncombustible

Boiling Point: 270°C

Melting Point: 2.7°C

Permissible Exposure Limits in Air
- 1 mg/m^3 (0.2 ppm) 10-hour TWA NIOSH and OSHA

Immediately Dangerous to Life or Health Concentration
- 80 mg/m^3 (20 ppm)

Registry Toxic Chemicals Number
- WS5600000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or Eye Contact

Symptoms
- Dental erosion
- Irritation of eyes, nose
- Dry throat
- Pulmonary edema
- Emphysema
- Conjunctivitis
- Respiratory distress
- Abdominal cramps
- Mouth irritation
- Severe skin burn
- Tracheobronchitis
- Dermatitis
- Blindness

Target Organs
- Respiratory system
- Eyes
- Skin
- Teeth
- Lungs

Protective Equipment Requirements
- Prevent any possibility of liquid contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing should be Changed Daily
- If there is any possibility that clothing may be contaminated.

Remove Clothing
- Immediately if it is non-impervious and becomes contaminated

Wear Eye Protection to Prevent
- Any possibility of eye contact

The Following Equipment Should Be Available
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 50 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Gas mask with acid gas canister, chin-style or front- or back-mounted with high efficiency particulate filter
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- 100 mg/m^3
  - Type C supplied-air respirator with full facepiece, operated in pressure demand or positive-pressure mode or operated in continuous-flow mode with full facepiece, helmet or hood
- Escape
  - Gas mask, chin style or front-or back-mounted with acid gas canister with high-efficiency particulate filter
  - Self-contained breathing apparatus with full facepiece
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Immediately when skin becomes contaminated

First Aid
- If sulfuric acid gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical
- If this chemical gets on skin, immediately flush skin with water. If it soaks or penetrates clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- If the chemical has been swallowed, and the person is conscious, immediately give him large quantitites of water to dilute the chemical. Do not attempt to make the exposed person vomit. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Physcial examination with emphasis on chronic respiratory disease
- Pulmonary functions
- 14 by 17 chest P.A. X-ray
- Vision test
- Eye disease check
- Gums and teeth exam
- Skin exam
- EKG recommended if employee to wear full-face respirator
- Pre-placement and annual exams

- X-Ray, repeat when pulmonary results or other respiratory tests indicated

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- Keep material out of water sources and sewers
- Apply water spray to knock down vapor
- Vapor knockdown water is corrosive and should be contained
- Neutralize spilled material with crushed limestone, soda ash or lime

Personnel Danger Situation Protection
- Keep upwind
- Avoid breathing vapors
- Avoid bodily contact with material
- Do not handle broken packages without protective equipment
- Wear full protective clothing (fireman's gear inadequate)
- Wear boots, protective gloves and gas-tight goggles.
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Collect solid substance in most safe way for reclamation
- Absorb in vermiculite, dry sand, earth or similar material and place in secured sanitary landfill
- For pits, lagoons, pools, or surface impoundments, waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

TALC (9.1)

Occurrence
- Pigment filler/coating (printing paper and linerboard)
- Pitch control agent

Synonym(s)
- Hydrous magnesium silicate
- Steatite talc
- Non-fibrous talc
- Non-asbestiform talc

Description
- Odorless solid/particulate, non-asbestos bearing, insoluble in water, carcinogen suspect

Melting Point: 900°C-1000°C

Permissible Exposure Limits in Air
- 20 mppcf
- 15 mppcf ACGIH
- 2 mg/m^3

Registry Toxic Chemicals Number
- VV8790000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Pneumoniosis
- Pulmonary fibrosis
- Ataxia
- Cough
- Pulmonary irritation

Target Organs
- Lungs
- Respiratory system
- Cardiovascular system

Protective Equipment Requirements
- Prevent skin contact

Wear Eye Protection to Prevent
- Reasonable probability of eye contact

Respirator Selection (Upper Limit Devices Permitted)
- 100 mppcf
    - Dust and mist respirator
- 200 mppcf
    - Dust and mist respirator, except single-use, except quarter-mask
    - Fume or high-efficiency particulate respirator
    - Supplied-air respirator
    - Self-contained breathing apparatus
- 1000 mppcf
    - High-efficiency particulate respirator with full facepiece
    - Supplied-air respirator with full facepiece, helmet or hood
    - Self-contained breathing apparatus with full facepiece
- 10,000 mppcf
    - Powered air-purifying respirator with high-efficiency particulate filter with full facepiece
    - Type C supplied-air respirator with full facepiece operated in pressure demand or positive-pressure mode or with full facepiece, helmet, or hood operated in continuous-flow mode
- Firefighting
    - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

First Aid
- If talc gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, immediately flush skin with water.
- If a person breathes in large amounts, move the exposed person to fresh air at once.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Physician examination
    - with empahsis on cardiovascular disease
- Attention to smoking, alcohol, medication and exposure to carcinogens
- History of asthma or allergies

- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- Pulmonary functions
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent--medical warning
- General cancer exam

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse dust
- Keep material out of water sources and sewers
- Use water spray to knock down dust

Personel Danger Situation Protection
- Avoid breathing dust
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- If body contact necessary, wear full protective gear

Waste Disposal Methods
- Collect solid substanct in most safe way for reclamation
- Place in secured sanitary landfill

TALL OIL (2.3)

Occurrence
- Kraft pulping by-product

Synonym(s)
- Tallol
- Liquid rosin

Description
- Mixture of rosin and fatty acids, obtained by acidification of the soap skimmings of black liquor, combustible, low toxicity

TEREPHTHALIC ACID

Occurrence
- NOHS walk-through

Synonym(s)
- Para-phthalic acid
- TPA
- Benzene-para-dicarboxylic acid

Description
- White crystals or powder, insoluble in water, combustible

Specific Gravity: 1.51

TERPINEOL

Occurrence
- NOHS walk-through

Synonym(s)
- Alpha-terpineol
- Beta-terpineol
- Gamma-terpineol
- Terpilenol

Description
- Colorless liquid or low melting transparent crystal, lilac odor, slightly soluble in water, combustible

TERPINOLENE

Occurrence
- NOHS walk-through

Synonym(s)
- 1,4(8)-Terpadiene

Description
- Water-white to pale amber liquid, insoluble in water

Specific Gravity: 0.864 (15.5°C/15.5°C)
Boiling Point: 183°C-185°C

TETRACHLOROCATECHOL (2.2)

(3.2)

Occurrence (4.2)
- Chlorination and extraction stage effluent in chemical bleaching (5.2)

TETRACHLOROETHYLENE (2.2)

(3.2)

Occurrence (4.2)
- NOHS walk-through (-.4)
- Final effluent

Synonym(s)
- Perchloroethylene
- Perk
- Nema
- Didakene
- Perclene

Description
- Colorless liquid, odor like ether/chloroform, noncombustible, carcinogen suspect

Boiling Point: 121°C
Solubility in Water, g/100 g water at 20°C: 0.15 g/ml
Melting Point: -22.2°C
Specific Gravity: 1.625 (20°C/20°C)

Permissible Concentrations in Water

- 5,280 micrograms/l (freshwater, acute)
- 840 micrograms/l (freshwater, chronic)
- 10,200 micrograms/l (saltwater, acute)
- 450 micrograms/l (saltwater, chronic)
- Perferably zero (human)

Permissible Exposure Limits in Air

- 100 ppm OSHA (670 mg/m^3) 8-hour TWA
- 200 ppm ceiling
- 300 ppm 5-minute ceiling
- 50 ppm ACGIH and NIOSH (335 mg/m^3) (skin)
- 100 ppm 5-minute ceiling NIOSH
- STEL 200 ppm ACGIH

Immediately Dangerous to Life or Health Concentration

- 500 ppm

Registry Toxic Chemicals Number

- KX385000

Route of Entry into Body

- Inhalation
- Ingestion
- Skin or eye contact

Symptoms

- Irritation of eye(s), nose
- Headache
- Nausea
- Vertigo
- Dizziness
- Loss of coordination
- Erythemia
- Hepatic degeneration
- Kidney damage
- Face/neck flush
- Liver damage
- Skin burn
- Narcosis
- Metallic taste
- Coma

Target Organs

- Liver
- Kidneys
- Eyes
- Respiratory system
- Central nervous system

Protective Equipment Requirements

- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

Employee Should Wash
- Promptly when skin becomes wet

Remove Clothing
- Immediately if it is non-impervious and becomes contaminated

The Following Equipment Should Be Available
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 500 ppm
  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid
- If tetrachloroethylene gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, get medical attention immediately. If medical attention is not available, get affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- With emphasis on renal and liver functions

- CBC
- Electro-cardiogram
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- CNS tests (peripheral neuropathy)
- Physician exam
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning
- Skin exam

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gases
- Keep material out of water sources and sewers
- Combustion products include corrosive or toxic vapors; thermal decomposition to phosgene can occur

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

TETRACHLOROGUAIACOL

(2.2)
(3.2)
(4.2)
(5.2)
(8.2)

Occurrence

- Chlorination and extraction stage effluent in chemical bleaching
- Final effluent

2-TETRAETHYLENE GLYCOL (2-ETHYLHEXOATE)

Occurrence

- NOHS walk-through

THIOUREA

Occurrence

- NOHS walk-through

Synonym(s)
- Thiocarbamide
- 2-thiourea
- Thu
- Sulourea
- USAF EK-497

Description
- White powder or crystals, lustrous, bitter taste, soluble in water, known carcinogen, suspected mutagen, skin irritant

Boiling Point: Decomposes
Melting Point: 180°C-182°C
Specific Gravity: 1.406
Registry Toxic Chemicals Number
- YU2800000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Hematopoietic blood changes
- Leukopenia
- Anemia
- Bone marrow depression
- Dermatitis
- Eczema
- Thyroid enlargement
- Hepatic cancer
- Thyroid cancer
- Skin irritation and sensitization
- Reproductive effects

Target Organs
- Blood
- Bone marrow
- Red blood cells
- White blood cells
- Endocrine system
- Skin
- Liver
- Reproductive system

Protective Equipment Requirements
Advise:
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
Advise:
- Any possibility of eye contact (faceshield or vented goggles)

Employee Should Wash
- Immediately when skin becomes contaminated

Work Clothing Should Be Changed Daily
Advise:
- If it is probable that clothing is contaminated, leaving clothing and equipment for decontamination and disposal

Remove Clothing
Advise:
- Promptly if it is non-impervious and contaminated and immediately if it is non-impervious and wet

The Following Equipment Should Be Available
Advise:
- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
In general:
  - Chemical cartridge respirator with organic vapor cartridge
- High levels
  - Self-contained breathing apparatus with full facepiece, helmet, or hood
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid
- If thiourea gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash skin with soap or mild detergent and water. If this chemical soaks clothing, immediately remove clothing and wash with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed and person is conscious, immediately give person large quantities of water. After water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Medical Surveillance
Advise:
- EKG recommended if employee to wear full-face respirator
- General medical history
- Industrial exposure history
- Physician exam
- Pre-placement and annual exams
- Attention to smoking, alcohol, medication and exposure to carcinogens
- Medical warnings for refusal of medical exam
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

- Mutagenic suspect agent -- medical warning
- Blood chemistry
- CBC
- With emphasis on liver disease
- With emphasis on blood disease
- History of hepatitis, blood transufusions, hospitalization
- Platelet count
- Thyroid tests
- Sensitization to substance
- Attention to liver size and density changes

Leaks and Spill Procedures

No OSHA/NIOSH data, but, due to hazardous nature of substance, advise following:

- Restrict persons without protective equipment until cleanup complete
- Keep material out of water sources and sewers
- Keep sparks, flames and other ignition sources away

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- If body contact necessary, wear full protection gear

Waste Disposal Methods

- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

TITANIUM DIOXIDE (9.1)

Occurrence

- Coating/pigment

Synonym(s)

- Anatase
- Brookite
- C.I. 77891
- RUNA RH20
- Titanox 2010
- Unitane 0-220
- Horsehead A-410

Description

- White powder, odorless

Boiling Point: less than 3000°C

Melting Point: 1640°C

Permissible Exposure Limits in Air

- 15 mg/m^3 (4 ppm)
- 10 mg/m^3 (total dust) ACGIH (5 mg/m^3 respirable dust)
- STEL 20 mg/m^3

Registry Toxic Chemicals Number
- XR2275000

Route of Entry into Body
- Inhalation

Symptoms
- Pulmonary irritation
- Animal symptoms:
  - Emphysema fibrosis

Target Organs
- Lungs

Protective Equipment Requirements
- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Work Clothing Should Be Changed Daily
- If there is any possibility that clothing may be contaminated

Remove Clothing

Advise:
- Promptly if it is non-impervious and contaminated

Respirator Selection (Upper Limit Devices Permitted)
- 75 mg/m^3
  - Dust and mist respirator
- 150 mg/m^3
  - Dust and mist respirator, except quarter-mask, except single-use
  - Fume or high-efficiency particulate respirator
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 750 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 7,500 mg/m^3
  - Powered air-purifying respirator with high efficiency filter
  - Type C supplied-air respirator operated in pressure demand, positive-pressure or continuous-flow mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

First Aid
- If a person breathes in large amounts of titanium dioxide, move the exposed person to fresh air at once. If breathing has stopped perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance
- General medical history
- Industrial exposure history
- Physical examination

- Respiratory history with emphasis on chronic respiratory disease
- Pulmonary functions
- 14 by 17 chest P.A. X-ray
- EKG recommended if employee to wear full-face respirator
- Periodic exam following exposure

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse dust
- Keep material out of water sources and sewers
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Avoid breathing dust
- Keep upwind
- Wear self-contained breathing apparatus
- Avoid bodily contact with material
- Wear boots, protective gloves and gas-tight goggles
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- If body contact necessary, wear full protective gear

Waste Disposal Methods
- Collect solid substance in most safe way for reclamation
- Place in secured sanitary landfill
- Absorb in vermiculite, dry sand, earth or similar material and place in secured sanitary landfill
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA. (RCRA).

TITANIUM SULFATE

Occurrence
- NOHS walk-through

Synonym(s)
- Titanic sulfate
- Basic titanium sulfate
- Titanyl sulfate

Description
- White cake-like solid, hygroscopic, soluble in water, toxic and irritating to skin and tissue

O-TOLIDINE (9.1)

Occurrence
- Dyes (benzidine-base)

Synonym(s)
- 3,3'-dimethylbenzidine

Description
- Combustible, sparingly soluble in water, low toxicity, benzidine-based dyes are potential carcinogens

TOLUENE

Occurrence
- Final effluent
- NOHS walk-through

Synonym(s)
- Toluol
- Methyl Benzene
- Phenyl Methane
- Methacide

Description
- Colorless liquid, benzene odor

Boiling Point: 110.5°C
Solubility in Water, g/100 g water at 20°C: 0.05%
Melting Point: -95°C

Permissible Concentrations in Water
- 17,500 micrograms/l (freshwater, acute)
- 6,300 micrograms/l (saltwater, acute)
- 5,000 micrograms/l (saltwater, chronic)
- 14.3 Mg/l (human)

Permissible Exposure Limits in Air
- 200 ppm TWA (8-hour)
- 300 ppm ceiling
- 500 ppm (10 minute peak)
- 200 ppm (10 minute peak) NIOSH
- 100 ppm (375 Mg/m^3) TWA ACGIH (skin) and NIOSH
- STEL 150 ppm (560 Mg/m^3) ACGIH (skin)

Immediately Dangerous to Life or Health Concentration
- 2000 ppm

Registry Toxic Chemicals Number
- XS5250000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Muscle fatigue
- Insomnia
- Paresthesias
- Fermatitis
- Photophobia
- Depression
- Reproductive effects

Target Organs
- Central nervous system
- Liver
- Kidneys
- Skin

Protective equipment requirements
- Prevent skin contact
- Wear impervious clothing and boots

- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Remove Clothing

- Immediately if it becomes wet to avoid flammability hazard

Wear Eye Protection to Prevent

- Any possibility of eye contact

The Following Equipment Should Be Available

- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 500 ppm
  - Chemical cartridge respirator with organic vapor cartridge
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 1,000 ppm
  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
- 2,000 ppm
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full face-piece operated in pressure demand or positive-pressure mode

Employee Should Wash

- Immediately when skin becomes contaminated

First Aid

- If toluene gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on the skin, immediately wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artifical respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
  - If the chemical has been swallowed, do not induce vomiting, but get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- CBC
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalyses
- EKG recommended if employee to wear full-face respirator
- Pulmonary functions
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warning to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If liquid, use paper towels to absorb small quantities. Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger.
- To evaporate, use fume hood
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Attempt to stop leak if without hazard
- Use water spray to knock down vapors

Personal Danger Situation Protection

- Keep upwind
- Do not handle broken packages without protective equipment
- Wear boots, protective gloves and gas-tight goggles
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Avoid breathing vapors

Waste Disposal Methods

- Incineration
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

O-TOLUIDINE

Occurrence

- NOHS walk-through

Synonym(s)

- Ortho-aminotoluene
- 1-methyl-2-aminobenzene
- 2-Aminotoluene
- O-methylaniline

Description

- Colorless to pale yellow liquid with a weak, aromatic odor, carcinogen suspect

Boiling Point: 199.4°C

Solubility in Water, g/100 g Water at 20°C: 1.5%

Melting Point: 129°C-131°C

Specific Gravity: 1.008

Permissible Exposure Limits in Air

- 5 ppm (22 mg/m^3) OSHA
- 2 ppm TWA ACGIH (9 mg/m^3)

Immediately Dangerous to Life or Health Concentration

- 100 ppm

TRIAZINE-FORMALDEHYDE RESIN

Occurrence

- NOHS walk-through

TRIAZINE-SULFONAMIDE RESIN

Occurrence

- NOHS walk-through

TRIBUTOXYETHYL PHOSPHATE

Occurrence

- NOHS walk-through

Description

- Slightly yellow, oily liquid, combustible, may be toxic

Specific Gravity: 1.020 (20°C)

Boiling Point: 215°C-228°C (4 mm)

TRIBUTYL CITRATE (9.1)

Occurrence

- Foam control agent

Synonym(s)

- Butyl citrate

Description

- Colorless or pale yellow, odorless, nonvolatile liquid, practically insoluble in water, combustible, low toxicity

Specific Gravity: 1.042 (25°C/25°C)

TRI-N-BUTYLAMINE

Occurrence

- NOHS walk-through

Description
- Pale yellow liquid with amine odor, slightly soluble in water, combustible, skin irritant, CNS stimulant

Specific Gravity: 0.8 (20°C/20°C)
Boiling Point: 214°C

TRIBUTYL PHOSPHATE (9.1)

Occurrence
- Foam control agent

Synonym(s)
- Tri-N-Butyl Phosphate
- TBP
- Celluphos 4
- Butyl Phosphate

Description
- Colorless to pale yellow, odorless liquid

Boiling Point: 293.3°C
Solubility in Water g/100 g Water at 20°C: 0.1%
Melting Point: -80°C
Permissible Exposure Limits in Air
- 5 mg/m^3 (0.5 ppm)
- 2.5 mg/m^3 ACGIH (0.2 ppm) TWA
- STEL 0.4 ppm (5 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 1300 mg/m^3 (119 ppm)

TRICHLOROCATECHOL (2.1)

(3.1)
Occurrence (4.1)
- Chlorination and extraction stage effluent in chemical bleaching (5.1)

1,1,1-TRICHLOROETHANE (2.2)

(3.2)
Occurrence (4.2)
- Slime control agent (5.2)
- Final effluent (7.2)

Synonym(s) (8.2)
- Methylchloroform (9.12)

Description (10.2)
- Colorless, nonflammable liquid; chloroform odor

Boiling Point: 74°C
Specific Gravity: 1.325
Permissible Concentrations in Water
- 1,030,000 micrograms/l (human)
- 18,000 micrograms/l (freshwater)
- 31,200 micrograms/l (saltwater)

Permissible Exposure Limits in Air
- 350 ppm (1900 mg/m^3) OSHA
- 350 ppm (15 minute ceiling) NIOSH (NIOSH now recommends 200 ppm)
- STEL 450 ppm (2,380 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 1000 ppm

Registry Toxic Chemicals Number
- KJ2975000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin and eye contact

Symptoms
- Dermatitis
- Conjunctivitis
- Dizziness
- Loss of coordination
- Drowsiness
- Increased reaction time
- Unconsciousness
- Death

Target Organs
- Skin
- Eyes
- Cardiovascular system
- Central nervous system

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact
- Wear protective clothing of leather, polyvinyl alcohol or neoprene

Work Clothing Should Be Changed Daily
- If contaminated

Remove Clothing
- Immediately if non-impervious and wet or contaminated

Respirator Selection
- 500 ppm
  - Chemical cartridge repirator with organic vapor cartridge(s)
  - Supplied air-respirator with full facepiece
  - Self-contained breathing apparatus with full facepiece
- 1000 ppm
  - Chemical cartridge respirator with organic vapor cartridge with full facepiece
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus

Employee Should Wash
- Promptly when skin becomes wet or contaminated

First Aid

- If 1,1,1-trichloroethane gets into the eyes, irrigate immediately
- If a person breathes in large amounts, move the exposed person to fresh air at once and perform artificial respiration.
- If the chemical is swallowed, get medical attention. Give large quantities of salt water and induce vomiting. Do not make an unconscious person vomit.

Medical Surveillance

- Expired air analyses
- Cardiac status
- Skin examinations
- Liver functions

Waste Disposal Methods

- Incinerate, preferrably after mixing wth another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. Alternative to disposal, trichloroethane may be recovered from waste gases and liquids from various processes and recycled.

TRICHLOROETHYLENE (2.2)

(4.2)

Occurrence (5.2)

- NOHS walk-through (7.2)
- Final effluent (8.2)

Synonym(s) (10.2)

- Trichloroethene (-.4)
- Dow-Tri
- Chlorylen
- Cecolene
- Trilene
- TCE
- Algylen

Description

- Colorless liquid, chloroform-like odor, noncombustible, carcinogen suspect

Boiling Point: 86.7°C

Solubility in Water, g/100 g water at 20°C: 0.1%

Melting Point: -73°C

Specific Gravity: 1.4649

Permissible Concentrations in Water

- 45,000 micrograms/l (freshwater, acute)
- 2,000 micrograms/l (saltwater, acute)
- Preferably zero (human)

Permissible Exposure Limits in Air

- 100 ppm (535 mg/m^3) TWA
- 200 ppm ceiling
- 300 ppm 5-minute ceiling
- 100 ppm TWA, 150 ppm 10-minute ceiling NIOSH
- 50 ppm (270 mg/m^3) TWA ACGIH
- STEL 150 ppm (805 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 1000 ppm

Registry Toxic Chemicals Number
- KX4550000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact

Symptoms
- Headache
- Nausea
- Vertigo
- Visual disturbance
- Tremors
- Narcosis
- Somnolence
- Dermatitis
- Cardiac arrhythmia
- Paresthesias
- Anesthesia
- Liver damage
- Irritability
- Central nervous system disturbance
- Vomiting

Target Organs
- Skin
- Liver
- Kidneys
- Heart
- Respiratory system
- Central nervous system

Protective Equipment Requirements
- Prevent skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance

Wear Eye Protection to Prevent
- Any possibility of eye contact

Remove Clothing
- Immediately if it is contaminated

The Following Equipment Should Be Available
- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)
- 500 ppm
  - Chemical cartridge respirator with organic vapor cartridge

    - Supplied-air respirator
    - Self-contained breathing apparatus
  - 1000 ppm
    - Chemical cartridge respirator with organic vapor cartridge with full facepiece
    - Gas mask with organic vapor canister, chin style or front- or back-mounted
    - Supplied-air respirator with full facepiece
    - Self-contained breathing apparatus with full facepiece
  - Escape
    - Gas mask with organic vapor canister, chin style or front- or back-mounted
    - Self-contained breathing apparatus
  - Firefighting
    - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash

- Immediately when skin becomes contaminated

First Aid

- If trichloroethylene gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When this chemical has been swallowed get medical attention immediately. If medical attention is not available, get affected person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on package. This non-prescription drug should be kept with emergency medical supplies in the workplace and is available at most drug counters. Do not make an unconscious person vomit.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Blood chemistry
- With emphasis on renal and liver functions
- CBC
- Pulmonary functions
- Electro-cardiogram
- Skin exam
- CNS tests (peripheral neuropathy)
- 14 by 17 chest P.A. X-ray
- Vision test

- Urinalysis
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gases
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- Keep material out of water sources and sewers
- Apply water spray to knock down vapors
- Combustion products include corrosive or toxic vapors

Personal Danger Situation Protection
- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods
- Absorb in vermiculite, dry sand, earth or similar material, and place in secured sanitary landfill
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device.
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

TRICHLOROFLUOROMETHANE (10.2)

Occurrence
- NOHS walk-through
- Final effluent (builders' paper and roofing felt process)

Synonym(s)
- Freon 11
- Fluorotrichloromethane
- Fluoroocarbon 11

Description
- Colorless, nearly odorless liquid, noncombustible, toxic by ingestion

Specific Gravity: 1.494 (17.2°C)

Boiling Point: 23.7°C

Permissible Exposure Limits in Air
- 1000 ppm

Registry Toxic Chemicals Number
- PB6125000

TRICHLOROGUAIACOL (2.2)

(3.2)
Occurrence (4.2)
- Chlorination stage effluent in chemical bleaching (5.2)
- Final effluent (8.2)

Registry Toxic Chemicals Number
- SL8200000

2,4,6-TRICHLOROPHENOL (2.2)

(3.2)
Occurrence (4.2)
- Final effluent (kraft and deinking processes) (5.2)
- Effluent from chlorination and extraction stages in chemical bleaching (8.2)

Synonym(s)
- 2,4,6-TCP

Description
- Yellow flakes with strong phenolic odor, noncombustible, skin irritant, carcinogen

Specific Gravity: 1.675 (25°C/4°C)
Boiling Point: 248°C-249°C
Melting Point: 69°C
Permissible Concentrations in Water
- 970 micrograms/l (freshwater, chronic)
- Preferably zero (human)

Registry Toxic Chemicals Number
- SN1575000

1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE

Occurrence
- NOHS walk-through

Synonym(s)
- Refrigerant 113
- Halocarbon 113
- TTE
- UCON 113

Description
- Colorless liquid with an odor like carbon tetrachloride at high concentrations, noncombustible

Boiling Point: 47.6°C
Solubility in Water, g/100 g water at 20C: 0.028%
Melting Point: -35°C
Specific Gravity: 1.42 (25°C)
Permissible Exposure Limits in Air
- 1000 ppm (7600 mg/m^3)

Registry Toxic Chemicals Number
- KJ4000000

TRIDECYL ALCOHOL (9.1)

Occurrence
- Foam control agent

Synonym(s)
- Tridecanol

Description
- Low-melting, white solid, pleasant odor, combustible, low toxicity

Boiling Point: 274°C
Melting Point: 31°C
Specific Gravity: 0.845 (20°C/20°C)

TRIETHANOLAMINE (9.1)

Occurrence
- NOHS walk-through (emulsifier)

Synonym(s)
- TEA
- Tri(2-hyroxyethyl)amine

Description
- Colorless, viscous, hygroscopic liquid, slight ammoniacal odor, miscible with water, combustible, low toxicity.

Specific Gravity: 1.126
Melting Point: 21.2°C
Boiling Point: 335°C

TRIETHYLENETETRAMINE

Occurrence
- NOHS walk-through

Synonym(s)
- Teta
- DEH 24
- Trien
- Tecza
- N,N-bis(2-aminoethyl)ethylenediamine
- 3,6-Diazaoctane-1,8-diamine

Description
- Yellowish liquid, low viscosity, mild ammonia-type odor, soluble in water, strong irritant to tissue, causes skin and eye burns, combustible

Boiling Point: 277.5°C
Melting Point: 12°C
Specific Gravity: 0.9818 (20°C/20°C)

TRIHYDROXYETHYLAMINE OLEATE (9.1)

Occurrence
- Surfactant

Synonym(s)
- Triethanolamine oleate

Description
- Combustible

TRIMETHYLAMINE

Occurrence
- NOHS walk-through

Synonym(s)
- N,N-dimethyl methanamine
- TMA

Description
- Colorless gas, strong base-fishy odor at low concentrations, becomes ammonia-like odor at higher concentrations

Boiling Point: -4°C
Solubility in Water, g/100 g water at 20°C 47.5%
Specific Gravity: 0.662 (-5°C)
Permissible Exposure Limits in Air
- 1 ppm (2.4 mg/m^3) ACGIH 8-hour TWA

Registry Toxic Chemicals Number
- PA0350000

TRIMETHYLOLMELAMINE (9.1)

Occurrence
- Starting material for melamine resins

2,2,4-TRIMETHYL-1,3-PENTANEDIOL MONOISOBUTYRATE

Occurrence
- NOHS Walk-Through

Description
- Combustible liquid, insoluble in water

Specific Gravity: 0.945-0.955 (20°C/20°C)
Boiling Point: 180°C-182°C (125 mm)

TRIPROPYLENE GLYCOL MONOMETHYL ETHER (-.4)

Occurrence
- Hydraulic fluid

Description
- Colorless liquid, soluble in water, combustible, low toxicity

Specific Gravity: 0.961 (25°C)
Boiling Point: 242°C (116°C at 10 mm)

TRISODIUM HYDROXYETHYLETHYLENEDIAMINETRIACETATE (6.1)

Occurrence
- Sequestering agent in oxidative bleaching (mechanical pulp)

Description
- Liquid

Specific Gravity: 1.285

TRISODIUM PHOSPHATE, CHLORINATED

Occurrence
- NOHS walk-through

Description
- Mixture of sodium hypochlorite and trisodium phosphate dodecahydrate, has properties of both when in solution, white, crystalline solid, soluble in water, moderately toxic, skin and eye irritant

TURPENTINE (2.3)

Occurrence
- By-product of kraft pulping (at digester)

Synonym(s)
- Gumspirits

Physical description
- Colorless liquid with a characteristic paint odor, insoluble in water

Boiling Point: 150°C-180°C

Melting Point: -50°C-60°C

Permissible Exposure Limits in Air
- 100 ppm (560 mg/m^3)
- STEL 150 ppm (840 mg/m^3)

Immediately Dangerous to Life or Health Concentration
- 1900 ppm

Registry Toxic Chemicals Number
- Y08400000

Route of Entry into Body
- Inhalation
- Skin absorption
- Ingestion
- Skin or eye contact

Symptoms
- Irritation of eyes, nose
- Dry throat
- Headache
- Vertigo
- Hematuria
- Albuminuria
- Skin irritation
- Dark urine, pain
- Unconsciousness
- Irritation of mucous membranes
- Convulsions

Target organs
- Skin
- Eyes
- Kidneys
- Respiratory system

Protective Equipment Requirements
- Prevent repeated or prolonged skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store in fireproof container

Work Clothing Should Be Changed Daily
- If there is any possibility that clothing may be contaminated

Remove Clothing
- Immediately if it becomes wet to avoid flammability hazard

Wear Eye Protection to Prevent
- Any possibility of eye contact (face shield or vented goggles)

The Following Equipment Should Be Available
- Eyewash

Respirator Selection (Upper Limit Devices Permitted)
- 1000 ppm
  - Chemical cartridge respirator with organic vapor cartridge, with full facepiece
- 1900 ppm
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- Escape
  - Gas mask with organic vapor canister, chin-style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

Employee Should Wash
- Promptly when skin becomes contaminated

First Aid
- If turpentine gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If this chemical gets on skin, flush skin with water. If it soaks through the clothing, immediately remove the clothing and flush the skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial

respiration. Keep affected person warm and at rest. Get medical attention as soon as possible.
- If the chemical has been swallowed. DO NOT induce vomiting. Get medical attention immediately.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Skin exam with emphasis on liver disease
- Blood chemistry
  - With emphasis on renal and liver functions
  - With emphasis on kidney functions
  - With emphasis on chronic respiratory disease
- Pulmonary functions
- 14 by 17 chest P.A. X-ray
- EKG recommended if employee to wear full-face respirator
- Periodic exam following exposure

Leaks and Spill Procedure
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers
- Use water spray to knock down vapors

Personal Danger Situation Protection
- Keep upwind
- Do not handle broken packages without protective equipment
- Wear boots, protective gloves and gas-tight goggles
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water
- Avoid breathing vapors

Waste Disposal Methods
- Do not dump unneutralized substance in sewer due to explosivity
- Atomize large quantities in suitable combustion chamber equipped with proper effluent gas cleaning device
- For pits, lagoons, pools, or surface impoundments waste must be contained through impermeable liner for life of facility. Controls for overtopping, flooding or other spurious discharge required by EPA (RCRA).

UREA (9.1)

Occurrence
- Reduction of color viscosity
- Humectant

Synonym(s)
- Carbonide

Description
- White crystals or powder, almost odorless, saline taste, soluble in water, low toxicity, noncombustible

Specific Gravity: 1.335
Melting Point: 132.7°C
Boiling Point: Decomposes
Registry Toxic Chemicals Number
- YR6250000

UREA-FORMALDEHYDE RESIN (9.1)

Occurrence
- Filler and coating
- Wet-strength/dry-strength agent
- Humectant

Description
- Urea and formaldehyde are combined in presence of pyridine, ammonia or an alcohol (with heat and pH controlled) to form intermediates; molding powders are then produced when fillers are added

VANILLIN (4.3)

Occurrence
- Recovered from sulfite process as by-product

Synonym(s)
- 3-Methoxy-4-hydroxybenzaldehyde
- Vanillic aldehyde

Description
- White crystalline needles, sweetish smell, soluble in 125 parts of water, combustible, low toxicity

Specific Gravity: 1.056
Melting Point: 81°C-83°C
Boiling Point: 285°C

VINYL CHLORIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Chloroethylene
- Chloroethene
- Monochloroethylene
- VC
- VCM
- Vinyl chloride monomer

Description
- Colorless odorless gas, or liquid with sweet odor when cold, insoluble in water, combustible, carcinogen and mutagen suspect

Boiling Point: -13.9°C

Specific Gravity: 0.9121 (liquid, 20°C/20°C)
Permissible Exposure Limits in Air
- 1 ppm OSHA 8-hour TWA
- 5 ppm 15-minute OSHA ceiling

XYLENE (2.2)

(3.2)

Occurrence (4.2)
- NOHS walk-through (5.2)
- Final effluent (7.2)

Synonym(s) (8.2)
- XYLOL (9.2)
- Dimethylbenzene (10.2)
- Violet 3

Description
- Colorless liquid with aromatic odors, combustible, carcinogen suspect

Boiling Point: 144.4°C
Solubility in Water, g/100 g water at 20°C: 0.00003%
Melting Point: -24.4°C
Specific Gravity: 0.86
Permissible Concentration in Water
- 6,000 micrograms/l (EPA suggests)

Permissible Exposure Limits in Air
- 100 ppm (435 mg/m^3) NIOSH
- STEL 150 ppm (655 mg/m^3) ACGIH

Immediately Dangerous to Life or Health Concentration
- 10,000 ppm (43,354 mg/m^3)

Registry Toxic Chemicals Number
- ZE2100000

Route of Entry into Body
- Inhalation
- Ingestion
- Skin or eye contact
- Skin absorption

Symptoms
- Dizziness
- Paresthesias
- Drowsiness
- Incoordination
- Irritation of eye(s)
- Dry throat
- Anorexia
- Nausea
- Vomiting
- Dermatitis
- Nose irritation
- Abdominal cramps
- Central nervous system depression

Target Organs
- Central nervous system
- Eyes

- Gastrointestinal system
- Blood
- Liver
- Teeth
- Skin

Protective Equipment Requirements

- Prevent any possibility of skin contact
- Wear impervious clothing and boots
- Wear gloves
- Wear faceshield (8 inch minimum)
- Provide container to store clothing until laundered or discarded
- Wear goggles - splash proof/dust proof
- Inform persons handling contaminated clothing of hazardous properties of substance
- Store used clothing in fireproof container

Employee Should Wash

- Promptly when skin becomes contaminated

Work Clothing Should Be Changed Daily

- If there is any possibility that clothing may be contaminated

Remove Clothing

- Immediately if it becomes wet to avoid flammability hazard

The Following Equipment Should Be Available

- Eyewash, quick drench
- No food or drink in work area
- Water fountain prohibited in work area
- Closed system if substance to be used

Respirator Selection (Upper Limit Devices Permitted)

- 1000 ppm
  - Chemical cartridge respirator with organic vapor cartridge and full facepiece
- 5000 ppm
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 10,000 ppm
  - Type C supplied-air respirator with full facepiece, helmet, or hood operated in pressure demand or positive-pressure mode or in continuous flow mode
- Escape
  - Gas mask with organic vapor canister, chin style or front- or back-mounted
  - Self-contained breathing apparatus
- Firefighting
  - Self-contained breathing apparatus with full facepiece, operated in pressure demand or positive-pressure mode

First Aid

- If xylene gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- If this chemical gets on skin, wash skin with soap or mild detergent and water. If it soaks clothing, immediately remove clothing and wash skin with soap or mild detergent and water. Get medical attention promptly.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.
- When the chemical has been swallowed, do not induce vomiting. Get medical attention immediately.

Medical Surveillance

- General medical history
- Industrial exposure history
- Respiratory history
- Physician exam
- Eye disease check
- Gastrointestinal check
- Emphasis on blood disease
- Blood chemistry
- With emphasis on renal and liver functions
- With emphasis on kidneys
- Skin exam
- CBC
- Hematology
- Urinalysis
- Pre-placement and annual exams
- Attention to smoking, alcohol, medication and exposure to carcinogens
- General cancer exam
- Doctors, lawyers provide medical warnings to employees in writing
- Carcinogen suspect agent -- medical warning

Leaks and Spill Procedures

- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse fumes/gasses
- If liquid, use paper towels to absorb small quantities
- Burn towels in safe place away from combustibles. Avoid closed area for disposal due to explosive danger
- To evaporate, use fume hood
- Keep material out of water sources and sewers
- Keep sparks, flames and other ignition sources away
- Use water spray to knock down vapors
- Attempt to stop leak if without hazard

Personal Danger Situation Protection

- Keep upwind
- Wear boots, protective gloves and gas-tight goggles
- Avoid breathing vapors or dust
- Do not handle broken packages without protective equipment
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

Waste Disposal Methods

- Collect solid substance in most safe way for reclamation
- Do not dump unneutralized substance in sewer due to explosivity
- Allow to melt and collect in safe way

- Atomize in suitable safe combustion chamber
- For pits, lagoons, pools or surface impoundments waste must be contained through impermeable liner for life of facility. Control for overtopping, flooding or other spurious discharge required by EPA (RCRA).

ZINC (-.2)

Occurrence
- NOHS walk-through
- Oil-fired power boiler emission (particulate)
- Final effluent

Description
- Shining white metal with blue luster, (zinc dust appears as gray powder), insoluble in water

Registry Toxic Chemicals Number
- ZG8600000

ZINC CHLORIDE

Occurrence
- NOHS walk-through

Synonym(s)
- Zinc Butter
- Zinc Dichloride

Description
- White fume, acrid odor, carcinogen suspect

Boiling Point: 732.2°C

Solubility in Water, g/100 g Water at 20°C: 81%

Permissible Exposure Limits in Air
- 1 mg/m^3

Registry Toxic Chemicals Number
- ZH1400000

ZINC HYDROSULFITE (6.1)

(8.1)

Occurrence
- Reductive bleaching for mechanical pulps
- Deinking

Synonym(s)
- Zinc dithionite

Physcial Description
- White solid, soluble in water, amorphous

ZINC OXIDE (9.1)

Occurrence
- Pigment

- Coating for photo-conductive reproduction paper
- Component of Lithopone (Griffith's zinc white)

Synonyms

- Calamine
- Amalox
- Ozide
- C.I. 77947
- EMAR
- Protox-type-168

Description

- White fume, irritating odor, insoluble in water

Boiling Point: sublimes

Melting Point: less than 163.8°C

Permissible Exposure Limits in Air

- 5 mg/m^3 (1.5 ppm) TWA (10-hour) NIOSH
- 15 mg/m^3 NIOSH (15-minute ceiling)
- STEL 10 mg/m^3

Registry Toxic Chemicals Number

- ZH4810000

Route of Entry into Body

- Inhalation

Symptoms

- Dry throat
- Chills
- Fever
- Pulmonary constriction
- Wheezing
- Headache
- Vomiting
- Fatigue
- Visual Disturbance

Target Organs

- Respiratory system
- Lungs

Protective Equipment Requirements

- Prevent skin contact
- Wear impervious clothing
- Wear gloves
- Wear faceshield (8 inch minimum)

Wear Eye Protection to Prevent

- Any possibility of eye contact

Work Clothing Should Be Changed Daily

Advise:

- If there is any possibility that clothing may be contaminated

Remove Clothing

Advise:

- Immediately if it is contaminated

The Following Equipment Should Be Available

Advise:

- Eyewash, quick drench

Respirator Selection (Upper Limit Devices Permitted)
- 50 mg/m^3
  - Fume or high-effficiency particulate respirator
  - Supplied-air respirator
  - Self-contained breathing apparatus
- 250 mg/m^3
  - High-efficiency particulate respirator with full facepiece
  - Supplied-air respirator with full facepiece, helmet, or hood
  - Self-contained breathing apparatus with full facepiece
- 2,500 mg/m^3
  - Powered air-purifying respirator with high-efficiency particulate filter
  - Type C supplied-air respirator operated in pressure demand or positive-pressure mode
- Firefighting
  - Self-contained breathing apparatus with full facepiece operated in pressure demand or positive-pressure mode

Employee Should Wash

Advise:
- Wash hands, arms, face, neck at each departure from work area.

First Aid
- If zinc oxide gets into the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
- If a person breathes in large amounts, move the exposed person to fresh air at once. If breathing has stopped, perform artifical respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Medical Surveillance
- General medical history
- Industrial exposure history
- Respiratory history
- Pre-placement and annual exams
- Pulmonary functions when physician believes it is warranted
- 14 by 17 chest P.A. X-ray
- Vision test
- Urinalysis
- EKG recommended if employee to wear fullface respirator
- Blood chemistry
- CBC
- Skin exam

Leaks and Spill Procedures
- Restrict persons without protective equipment until cleanup complete
- Ventilate to disperse dust
- Keep sparks, flames and other ignition sources away
- Keep material out of water sources and sewers

Personal Danger Situation Protection
- Avoid breathing dust
- Avoid bodily contact with material
- Wash away any materials which may have contacted the body with copious amounts of water or soap and water

- Do not handle broken packages without protective equipment
- Wear boots, protective gloves and gas-tight goggles
- Wear full protective clothing (fireman's gear inadequate)

Waste Disposal Methods

- Landfill

ZINC SULFIDE (9.1)

Occurrence

- Pigment filler/coating
- Component of Lithopone (Griffith's zinc white)

Synonym(s)

- Wurtzite (alpha-form)
- Sphalerite (beta-form)

Description

- Yellowish-white powder, stable if kept dry, insoluble in water, low toxicity

Specific Gravity: (alpha) 3.98
(beta) 4.102
Melting Point: (beta) changes to alpha-form at 1020°C
Boiling Point: (beta) 1180°C (sublimes)

APPENDIX B

INTERNAL PROCESS CONTROL MEASURES

INTERNAL PROCESS CONTROL MEASURES

In this appendix specific production process controls that are applicable to each Study Area and subcategory are described. These controls are representative of many alternative approaches taken within the pulp, paper and paperboard industry to implement measures to reduce effluent volume and waste loads. Such measures are commonly employed within the industry to control pulping, bleaching, washing, liquor recovery and papermaking operations. Their occurrences and general effectiveness as described in this appendix have been identified in various effluent limitation development documents (1,2,3,4,5).

Pollution abatement is not the sole driving force for implementation of production process controls. In many cases, the concern for consistent production of high quality products with minimum loss of substrate results in the development of process controls that reduce raw waste loadings. Production process controls have always been a part of integrated pulp and papermaking operations, their primary function being the control of product characteristics and improvement of process economics. The process controls discussed below, are presented in Table B-1. These process controls, which are grouped within specified mill areas, are numbered according to the numerical system in which they are illustrated in the Study Area process flow diagrams presented in Section 4.

WOODYARD/WOODROOM

Production process controls that reduce raw waste loading in woodroom areas include:

- Conversion to mechanical or dry systems or close-up of wet operations.

- Segregation and reuse of uncontaminated cooling waters.

These controls, their applicability within the various subcategories, and their general effectiveness are described below.

CLOSE-UP OR DRY OPERATION

This production process control is commonly practiced at most mills; however, it has not been commonly employed at mills in the dissolving sulfite pulp and groundwood-fine papers subcategories. For mills in the dissolving sulfite pulp subcategory, discharge of wastewater from hydraulic barking systems can be eliminated through installation of a collection tank and cleaning system to enable recycle of water. Pulp mill wastewater can be used as make-up to the system. At mills in the groundwood-fine papers subcategory, conversion to dry barking and the use of mechanical conveyors is possible. In colder climates it may be necessary to use steam in the barking drums.

Table B-1 PRODUCTION PROCESS CONTROL MEASURES FOR REDUCTION OF EFFLUENT VOLUME AND POLLUTANT LOADINGS

Woodyard/Woodroom
   1. Closeup or dry operation
   2. Segregate cooling water
Pulp Mill
   3. Reuse blow condensates
   4. Reduce thickener overflow (groundwood)
   5. Spill collection
Brown Stock Washers and Screen Room
   6. Add third or fourth stage washer
   7. Recycle more decker filtrate
   8. Cleaner rejects to landfill
Bleaching Systems
   9. Countercurrent or jumpstage wash
   10. Evaporate caustic extraction stage filtrate
Evaporation and Recovery
   11. Recycle of condensate
   12. Replace barometric condenser with surface condenser
   13. Boilout tank
   14. Neutralize spent sulfite liquor
   15. Segregate cooling water
   16. Spill collection
Liquor Preparation Area
   17. Installation of green liquor dregs filter
   18. Lime mud pond
   19. Spill collection
Papermill
   20. Spill collection
   21. Improvement of savealls
   22. Use of high pressure showers for wire and felt cleaning
   23. Whitewater use for vacuum pump sealing
   24. Papermachine whitewater use on wire cleaning showers
   25. Whitewater storage for upsets and pulper dilution
   26. Recycle of press water
   27. Reuse of vacuum pump water
   28. Additional broke storage
   29. Installation of wet lap machines or other screening devices
   30. Segregate cooling water
   31. Cleaner rejects to landfill
   32. Fourth stage cleaners
Steam Plant and Utility Areas
   33. Segregate cooling water
   34. Lagoon for boiler blowdown and backwash waters
35. Recycle of Treated Effluent
36. Chemical Substitution

Application of these controls in the barking area of the woodroom results in reduced water use and a lower water content in the bark. With drier bark, combustion (and heat reclamation) is possible without further processing.

Close-up of the woodroom by conversion to dry debarking or a closed-cycle hydraulic system typically results in flow reductions of 8.3 to 12.5 kl/kkg and TSS reductions in the range of 5 to 10 kg/kkg. Factors affecting the level of reduction are the source of water used in the woodroom, the type of barking operation employed, the type of wood processed, seasonal factors, and the ultimate disposal technique.

SEGREGATION OF COOLING WATER

This control item involves the collection of water used for motor, chip blower, and bearing cooling. This non-contact cooling water can be returned to an existing water collection tank. At mills in some subcategories, this control may also include the return of condensate from the heating system to the steam plant through a separate line.

Woodroom non-contact cooling water segregation has been neglected at most mills in the integrated subcategories, although it is an applicable production process control measure in the integrated subcategories where woodrooms are employed. Its implementation can result in a measurable flow reduction and significant energy savings. Segregation of cooling water via a separate discharge can result in effluent flow reductions in the range of 1.3 to 4.2 kl/kkg, depending on the subcategory. Little reduction in BOD_5 or TSS raw waste loads result from application of this measure.

PULP MILL

Production process controls that reduce raw waste loadings in the pulp mill areas include:

- Reuse of digester relief and blow condensates.
- Reduction of groundwood thickener overflow.
- Spill collection in the brown stock, digester, and liquor storage areas.

These controls and their applicability are described below.

REUSE RELIEF AND BLOW CONDENSATES

Digester relief and blow condensates may be major contributors to the total BOD_5 discharge from a mill. Particularly with continuous digesters, the relatively small flows are highly contaminated with foul smelling organic mercaptans and other organic compounds. This control is an applicable measure for all of the kraft and soda subcategories. Digester blow condensate is collected in a tank and pumped to the area of greatest benefit. The collection tank should be equipped with a conductivity alarm to alert the operator of unusually strong condensate. Areas where blow condensates can be reused include: a) addition at the salt cake dissolving tank and b) use at the lime kiln for mud washing.

If digester condensates, including relief condensates, are stripped or further treated (i.e., reverse osmosis) to reduce BOD_5, they can be reused in other process areas including a) addition at the first shower of the last stage brown stock washer or b) addition directly to the black liquor.

Wastewater BOD_5 reductions ranging from 0.9 to 3.0 kg/kkg can be achieved by incorporating digester relief and blow condensates back into the black liquor recovery cycle. Wastewater reduction at alkaline (kraft and soda) pulp mills through the reuse of increasingly dirtier condensates to replace fresh water results in higher concentrations of volatile organic sulfur compounds in wash water and dilution water. While a net reduction in BOD_5 may result, the possibility of releasing these volatile compounds through brown stock washer vents, screening operations, and smelt tank dissolving operations is increased.

REDUCE GROUNDWOOD THICKENER OVERFLOW

At a typical mill in the groundwood-fine papers subcategory, excess thickener filtrate overflows to the sewer at a rate of up to 16.7 kl/kkg of pulp produced. This overflow represents a small source of fiber loss and contributes 5.0 kg/kkg of TSS at a typical mill. Modifications to close up the white water system, essentially eliminates thickener filtrate overflow to the sewer. A small bleed is maintained to control the build-up of pulp fines in the final accepted groundwood. Water make-up to the groundwood system is excess papermachine white water. A heat exchanger is required during the warmer months of the year to control heat build-up in the filtrate. Fresh water used as cooling water in the heat exchanger is subsequently returned as make-up to the papermachine systems or discharged via the thermal sewer to balance mill white water heat load.

SPILL COLLECTION

Improved spill collection systems can be employed in the digester, liquor storage, and brown stock areas. A system designed to recover leaks, spills, dumps, and weak liquor overflows results in a recovery of approximately 1.5 to 3.5 kg/kkg of BOD_5. In the brown stock area, the combination of stock and liquor spills is generally combined with the brown stock entering the first stage washer vat. This control is an applicable measure in ten subcategories.

A separate spill collection system can be employed using a sump in conjunction with conductivity measurements to detect and collect any leaks, spills, or overflows from the pulp mill digester and liquor storage tanks. Any liquor recovered can be diverted to its appropriate tank or to a spare liquor tank. This measure is appropriate for the dissolving, market, BCT (paperboard, coarse, and tissue), and fine bleached kraft and soda subcategories. Modified systems can also be used in the three sulfite and some groundwood and deink subcategories.

BROWN STOCK WASHERS AND SCREEN ROOM

Production process controls that reduce raw waste loadings in the washer and screen room areas include:

- Addition of a third or fourth stage washer or improved washing efficiency by replacement with a properly sized system.
- Recycle of more decker filtrate.
- Discharge of cleaner rejects to a landfill.

ADDITION OF A THIRD- OR FOURTH-STAGE WASHER

This control is applicable to mills in the kraft, soda, NSSC, both papergrade sulfite, and deink (newsprint product sector) subcategories. The control includes the addition of a fourth-stage washer to all kraft and soda washing lines and a third stage washer to all NSSC and papergrade sulfite washing lines. This control is primarily a BOD_5 reduction measure as dissolved solid losses from the pulping operation are reduced.

Improved washing facilites bleaching and results in lower bleaching chemical costs. In terms of raw waste load, the main effect is a reduction in BOD_5 ranging from about 2.5 kg/kkg for dissolving kraft mills to as much as 4.0 kg/kkg.

RECYCLE OF MORE DECKER FILTRATE

This control item, which has been considered in the establishment of effluent limitations, is generally applicable to the alkaline (kraft and soda), groundwood, and deink subcategories. Thickening up by using decker filtrate on brown stock washer showers can substantially reduce decker filtrate overflow to the sewer, thus reducing effluent flow and BOD_5. Efficient washing on the decker is required to reduce liquor carry-over to bleaching. At many mills in the subcategories mentioned, a considerable quantity of decker filtrate is reused in the screen room as dilution water.

Typically, reductions of about 4.2 kl/kkg of flow and 0.5 to 1.0 kg/kkg of BOD_5 can be realized through implementation of this production process control. Use of this measure requires a detailed study at each mill; the efficiency of the existing washing and screening systems should be taken into account prior to further modification. This production process control is now being practiced to a limited degree and can be considered as an applicable control measure at new source mills.

CLEANER REJECTS TO LANDFILL

Centricleaner rejects and continuous screen rejects from the screen room are generally sewered directly and processed in a wastewater treatment plant. Most of these rejects are removed in the primary clarifier and handled in the solids dewatering system; primary solids are often mixed with solids from the secondary clarifier. Dry collection of screen and cleaner rejects with separate discharge to a landfill will reduce TSS raw waste loads.

Typically 2.0 to 3.0 kg/kkg of TSS can be removed from the raw waste in most of the integrated subcategores. However, this may not affect final effluent characteristics, depending on the existing primary clarifier solids loading. If the clarifier is overloaded, TSS reduction can have an appreciable effect on overall treatment plant performance. If the existing clarifier can readily accommodate this loading, it may be advantageous to continue sewering these wastes. The accompanying fibrous material, when mixed with biological solids, can aid in dewatering of the combined solids. This measure is considered appropriate for the "tissue from wastepaper" subcategory for the purpose of purging dirt from the effluent; this allows for recycle of effluent and recycle of sludge to the furnish.

BLEACHING SYSTEMS

The extent of bleaching varies widely within the industry. Single stage operations are often used at groundwood and deink mills, while three bleaching stages are common at sulfite and semi-bleached kraft mills. Five or six stages are often used at fully bleached kraft mills.. In multi-stage bleaching, effluents from the first two stages are commonly sewered, although some of the first stage chlorination filtrate may be used to dilute incoming washed brown stock. Bleachery effluent is a major source of process wastewater discharged from integrated bleached kraft and sulfite mills. The following measures address steps that may be used to reduce effluent flow from multi-stage bleacheries.

COUNTERCURRENT OR JUMP-STAGE WASHING

This control is applicable at all kraft and soda mills and at many sulfite mills. In jump-stage washing, the filtrate from the second chlorine dioxide washer is used on the showers if the first chlorine dioxide washer; the filtrate from the first chlorine dioxide washer is then used on the showers of the chlorine washer. Jump-stage washing, instead of straight countercurrent washing, is necessary if the first and second caustic washers are constructed of materials that are not sufficiently corrosion resistant (i.e., 304 stainless steel or rubber covered carbon steel rather than the more resistant 317 stainless steel or titanium). Water reduction to levels typical of the discharge from three stage bleacheries may be obtained by this method.

In newer mills, where all bleach plant washers, pumps, pipelines, repulpers, and other equipment are constructed of 317 stainless steel or equivalent, full countercurrent washing may be practiced. Fresh water or preferably pulp machine or papermachine white water is used for the last stage washer showers and for dilution after high density bleached pulp storage. All washer filtrate is used on showers and for dilution of pulp from the preceding stage. Compared to a bleach plant with all fresh water showers, the conversion to full countercurrent washing can reduce bleach plant effluent volume by up to 80 percent.

Full countercurrent bleaching using chlorine dioxide necessitates the use of 317 stainless steel or titanium materials for all washers, pumps, and pipelines in the system. If not already in place, such equipment is extremely expensive; by contrast, jump-stage washing sequences can often be readily implemented using existing major equipment with relatively minor alterations, such as the addition of pumps and pipelines to service additional showers.

Earlier studies proposed the use of full countercurrent washing or jump-stage washing in multi-stage kraft and soda pulp mill bleach plants. Jump-stage washing or modifications of such a system are utilized at many mills. Bleach plant water use has declined sharply as a result of these changes. Flow reductions of 8.3 to 25.0 kl/kkg are possible through improved countercurrent reuse of filtrates in the bleaching sequence at mills in the alkaline (kraft and soda) and sulfite subcategories. For the simpler papergrade sulfite bleach plants, savings would be about 29.2 kl/kkg.

EVAPORATE CAUSTIC EXTRACTION STAGE FILTRATE

This control is an applicable control measure at mills in the dissolving sulfite pulp subcategory. The hot caustic extraction would have a three-stage washing system similar to a red stock washer with carefully controlled hot showers. The effluent from this stage can be evaporated and incinerated or disposed of separately from the rest of the bleachery effluent; therefore, flow can be kept at a minimum. This control greatly reduces BOD_5 loadings, from 41.4 to 104.4 kg/kkg, depending upon the grade of dissolving sulfite pulp produced.

EVAPORATION AND RECOVERY

Production process controls that reduce raw waste loadings in the evaporator and recovery areas include:

- Recycle of condensates.
- Replacement of the barometric condenser with a surface condenser.
- Addition of a boil-out tank.
- Neutralization of spent sulfite liquor.
- Segregation of cooling water.
- Various spill collection measures.

RECYCLE OF CONDENSATES

Only in the BCT (paperboard, coarse, and tissue) bleached kraft and the semi-chemical subcategories is extensive increased recycle of condensate feasible when compared to present modes of operation. At BCT bleached kraft mills, improved use of condensate can eliminate up to 7.5 kg/kkg of BOD_5 from the raw waste. At semi-chemical mills, where lower levels of substrate are dissolved, the reuse of condensate represents a far lower BOD_5 saving, generally less than 0.25 kg/kkg.

REPLACE BAROMETRIC CONDENSER

At most mills in all integrated subcategories, except for dissolving kraft, surface condensers are used. Similarly, in the dissolving kraft subcategory, barometric condensers can be replaced with surface condensers, thus assuring a clean, warm condenser water stream that can be reused. This also results in a smaller concentrated stream of condensate that may be reused in the causticizing area or in the brown stock washer area or that can be steam stripped and reused for other purposes. Existing barometric condenser seal tanks can be reused as the seal tanks for new surface condensers. The air ejectors would be retained as stand-by, for use during system start-up. A cooling water pump can be provided to pump mill process water through the condenser and return it to the process water main.

In summer, the cooling water may be too hot to return entirely to the process. Automatic temperature control can be implemented to divert excess water to a non-contact water thermal sewer and return only an acceptable amount to the process water line. The condensate pump provides water to the required discharge point or to washers where the condensate can be reused. This measure results in less than a 0.5 kg/kkg BOD_5 reduction and less than a 4.2 kl/kkg flow reduction.

ADDITION OF A BOILOUT TANK

This control is applicable at mills in the dissolving kraft and market bleached kraft subcategories. Water for the boilout is pumped to the evaporators from the boilout tank, which is full at the start of the process. When the concentration of the black liquor from the evaporators starts to decrease, the flow is diverted to the weak black liquor tank. When the concentration decreases further to a predetermined value, the flow can be diverted to the boilout tank. Overflow from the condensate tank, which occurs during boilout because of an increased rate of evaporation, can also be diverted to the boilout tank. After the boilout is complete and weak black liquor is again fed to the evaporator, weak black liquor flow can be initially diverted to the weak black liquor tank and eventually to the strong black liquor tank.

NEUTRALIZE SPENT SULFITE LIQUOR

In the dissolving and papergrade sulfite subcategories (particularly at mills with MgO systems), neutralization of spent sulfite liquor before evaporation will reduce raw waste loadings of BOD_5. Neutralization gives a significant reduction in the carry-over of organic compounds to the condensate. Depending on the mode of operation, this reduction can range from 1.0 to 1.5 kg/kkg of BOD_5 at papergrade sulfite mills and up to 25.0 kg/kkg of BOD_5 at dissolving sulfite mills. At sulfite mills where a MgO or a sodium base is not used, an organics removal system can be used to enable recycle of evaporator condensate. The reduction in BOD_5 load is of the same order of magnitude as with spent sulfite liquor neutralization, but can involve a greater capital cost. Organics removal is essential to prevent build-up in the system when extensive condensate recycle is practiced. At most mills where this measure is applicable, this control strategy is now practiced.

SEGREGATION OF COOLING WATER

Segregation and reuse of cooling water in the evaporator and recovery area of semi-chemical mills can result in substantial flow reductions, giving flow reductions of approximately 1.7 kl/kkg. At some of these mills, extensive reuse of cooling water is practiced; however, smaller streams are typically discharged to the sewer. Elimination of the discharge of these sewered streams reduces the flow to the treatment facility. The equipment requirements are similar to those for the woodroom area.

SPILL COLLECTION

Spill collection in the evaporator, recovery, causticizing, and liquor storage areas can be practiced to varying degrees at mills in three kraft subcategories. The spill collection system applicable at mills in each subcategory varies widely, depending on the existing level of implementation. This measure involves the use of the following techniques, all of which are being used at some mills in certain subcategories:

- Spill collection in the evaporator and recovery boiler area,
- Spill collection in the liquor storage area,
- Spill collection in the causticizing area, and
- Addition of a spare liquor tank to accept spills from any of these three areas and a pump to return a spill to its point of origin.

All spill collection systems involve the use of a sump and a pump to divert the spill to the spill tank. If the tank is full, spills can be diverted to a spill lagoon. The spill collection sump for the liquor storage area can be equipped with a conductivity controller which allows surface run-off and low conductivity spills to be diverted to the spill lagoon, while allowing high conductivity spills to be sent to the spill tank for recovery.

LIQUOR PREPARATION AREA

Production process controls that reduce raw waste loads in the liquor preparation area include installation of a green liquor dregs filter and lime mud pond, as described below.

INSTALLATION OF GREEN LIQUOR DREGS FILTER

At an alkaline (kraft or soda) pulp mill with a modern recovery furnance, green liquor dregs contribute approximately 5.0 kg/kkg of TSS. Diversion of this material from the primary clarifier can have a beneficial effect. The dregs are usually pumped from a gravity-type dregs washer or clarifier at very low consistencies with accompanying high strength alkaline liquor entrainment. This may have an appreciable effect on pH at the clarifier. In addition, the material tends to be of a fine colloidal nature and can be difficult to settle.

At many modern mills, belt-type filters have been installed to improve washing and sodium recovery from the dregs. This results in a drier material that can readily be disposed of at a landfill site. For mills having only a gravity type unit, a small vacuum filter can be employed. Condensate can be applied for washing the cake on the filter with subsequent use of the filtrate in the dregs washer itself. This creates a countercurrent system that is effective in the recovery of sodium and for dry dregs disposal. Generally, such projects are justified on the basis of alkali savings, depending on the capability of existing primary clarifier and sludge thickening operations. Such devices are generally applicable at all mills in the alkaline (kraft and soda) subcategories. However, if adequate primary clarification is provided, this measure may result in little improvement in overall treatment system performance.

INSTALLATION OF A LIME MUD POND, AND

SPILL COLLECTION

At kraft pulp mills, the use of a lime mud pond and/or a spill collection system can reduce TSS discharges caused by upsets, start-ups, and shutdowns in the white liquor clarification and mud washing area.

A spill collection diversion system, incorporating a pond for liquors containing high quantities of lime mud, allows for reuse of this mud. It also assures minimum upsets at the primary clarifier in the case of a dump of a unit containing high concentrations of lime. Such a dump could occur during a period of outage or repair. Typical long-term savings average 1.5 to 2.5 kg/kkg of TSS in kraft pulp mills. However, this control measure may result in little improvement in overall treatment system performance at facilities with adequate primary clarification. It may, however, be justified at many mills on the basis of the resulting savings in lime cost.

PAPERMILL

Production process controls that reduce raw waste loading in the papermill area include:

- Papermachine, bleached pulp (furnish), and color plant spill collection.
- Saveall improvements.
- High-pressure showers for wire and felt cleaning.
- White water use for vacuum pump sealing.
- White water showers for wire cleaning.
- White water storage for upsets and pulper dilution.
- Recycle of press effluent.
- Reuse of vacuum pump water.
- Provision for additional broke storage.
- Installation of wet lap machines.
- Segregation of cooling water.
- Collection of cleaner rejects for landfill disposal.
- Addition of fourth stage cleaners.

These specific controls, their applicability to the various subcategories and their general effectiveness are described individually in the following paragraphs.

SPILL COLLECTION

Papermachine and bleached pulp (furnish) storage area spill collection is applicable at mills in all of the bleached kraft and soda, sulfite, groundwood, and nonintegrated subcategories. The extent of application of this control varies by subcategory, depending on factors such as the number of machines and the extent to which spill collection already exists at the various mills. For the bleached kraft, soda, and sulfite subcategories, additional spill collection systems can be installed at many mills to handle overflows and equipment drains along with spills from the bleached stock storage area, the stock preparation areas, and the papermachine or pulp machine wet ends. These systems generally require installation of a new sump, a new stock tank, and a pump to return the spills to a point where they could be blended back into the process. This control can result in substantial stock savings and a reduction in TSS load. Savings estimates vary widely, but may typically be 2.0 to 2.5 kg/kkg of TSS and 0.6 to 0.8 kg/kkg of BOD_5.

Collection of color plant spills can be practiced at mills in all subcategories where fine coated papers are manufactured. One spill collection system can be applied for each machine which has a coater or size press. With this system, spills and wash water are collected in a sump and sorted for reuse. The system provides for control of spills in all the storage and mix tank areas of the color plant and at the coater, tanks, and screens. This control results in savings of expensive coating pigments and adhesives as well as a reduction in the TSS load.

IMPROVEMENT OF SAVEALLS

At most mills, savealls have been employed. The present emphasis on savealls is to improve their performance. Mills in many subcategories can benefit from saveall improvements such as the installation of new vacuum disc savealls or the reworking of existing savealls by adding some new equipment. Savealls can be employed on all types of machines producing all types of products including fine papers, board, tissue papers, molded products, and newsprint. Most of the savealls being installed today are the vacuum disc filter type. They are flexible in handling various types of stock and shock loadings and exhibit high separation efficiencies. As a control item, their use results in flow and solids reductions. Nearly all stock saved is stored or reused immediately. The clear white water can be readily reused within the mill, replacing some fresh water uses. If not reused, it becomes a relatively clear overflow to the sewer. Significant flow reductions can be attained when an effective saveall is used, in that extensive filtrate recycle becomes possible.

At mills with existing savealls, a new saveall can replace the existing saveall on the largest machine, making use of existing pumps, tanks, and piping. The existing saveall can be repiped for the next smaller machine, and so on down the line, so that each machine may have a larger, more effective saveall. The resulting overall white water balance determines the net savings, but flow reductions from about 0.8 to 4.7 kl/kkg are possible depending on the type of mill and level of white water reuse.

USE OF HIGH PRESSURE SHOWERS FOR WIRE AND FELT CLEANING

High pressure showers to replace low pressure, high volume showers (i.e., those used for felt cleaning, return wire cleaning, and couch roll cleaning) can save up to 90% of the water used in conventional shower applications and may be more effective. It is generally considered that felt cleaning showers are operated at 35.2 kg/cm^2 and fourdrinier showers at 21.1 kg/cm^2. High pressure showers are applicable at mills in the dissolving kraft, dissolving sulfite pulp, deink, nonintegrated-fine papers, nonintegrated-filter and nonwoven papers, and nonintegrated-lightweight papers subcategories. Application is however, generally universal in the industry.

WHITE WATER USE FOR VACUUM PUMP SEALING

Excess clarified white water has been successfully used to replace fresh water on mill vacuum pumps. The vacuum pump seal water may then be recycled or discharged. At a minimum, the equivalent quantity of fresh water use is directly displaced. Corrosion and abrasion, however, may be deterrents to the practice of this system, particularly at low pH or high filler levels. Fresh water addition may be required and can be provided to maintain temperatures below 32°C. This measure can be applied at mills in all subcategories. Resulting reductions in waste loadings depend on the overall water balance, but flows of 94.6 to 380 liters/minute per pump are common.

PAPERMACHINE WHITE WATER USE ON WIRE CLEANING SHOWERS

Clarified white water from the papermachine saveall, containing low levels of additives and fillers, can be used on wire cleaning showers. White water can be used on fourdrinier showers and knock-off showers. The system includes a white water supply pump, supply piping, and showers. A fresh water backup supply header is provided with controls for introduction of fresh water to the white water chest in the event of low volume in the chest. The effect of implementation of this control varies widely by machine and type of mill.

WHITE WATER STORAGE FOR UPSETS AND PULPER DILUTION

This system consists of an additional storage tank to store excess white water that overflows from the existing clear white water tank. Where possible, the tank can be adjacent to or added onto the existing tank to eliminate pumping costs. The white water from this tank can be used in the pulper or bleach plant. The tank can be sized to hold adequate white water needed for pulp dilution after pulping, bleach plant washing, or continuous washing requirements. A fresh header is provided to the tank for makeup.

A separate system may be needed for each machine, depending on the variability of furnish. Each machine may have its own pulper and require a completely separate white water system. Increased storage facilities can provide significant flow reductions; BOD_5 and TSS reductions may also result.

RECYCLE OF PRESS WATER

Effluent from the press section of a papermachine contains fibrous fines and fillers that can be reintroduced into the white water system and recovered. Water from the vacuum presses, as well as pressure rolls, can be piped to a collection tank (or wire pit) often without the need for pumping. From the tank, the water can be pumped to the saveall system to reclaim the fiber and fillers and to make the water available for use in the white water systems. This reduces solids and may reduce flow to the wastewater treatment plant. Generally, a separate system is required for each machine.

Felt hairs, previously a deterrent in some systems, have been largely eliminated with the advent of synthetic felts. Thus, provision for the removal of felt hairs has not been contemplated in the system, although such provision may be required on top-of-the-line printing or specialty grades, at least during periods of use of new felts.

REUSE OF VACUUM PUMP WATER

Recycle of vacuum pump water (most of which is seal water) and/or use of white water as seal water nearly eliminates fresh water additions for these uses. Installation of the system requires piping, a collection tank, and a pump to return the water to storage for reuse. One system is needed for each machine.

At many mills, specific collection systems are not employed for press effluent and vacuum pump seal water. By combining the two systems, cost reductions could be realized. Up to 21.0 kl/kkg may be saved. Typically, however, flow reductions are estimated at less than 8.3 kl/kkg.

ADDITIONAL BROKE STORAGE

An additional broke storage chest can be installed at most mills in the nonintegrated-lightweight papers subcategory. The system consists of a central broke storage chest, pumps, and piping. This enables excess broke to be brought to the chest and returned to the proper machine once the upset is over. At some mills, more than one chest would be required, depending on the number of machines and product mix. Generally, the tank is sized to hold 30 minutes of broke from the couch pit. It allows for breaks or grade changes to occur with a minimum of overflow to the sewers. Up to 10.0 kg/kkg TSS might be saved at a mill where grades are changed frequently.

INSTALLATION OF WET LAP MACHINES OR OTHER SCREENING DEVICES

Wet lap machines or other screening devices can be used at mills in some subcategories as part of an overall stock spill collection system. The wet lap machine can be preceded by a screen for removal of rejects and dirt from spilled stock. Rejects are hauled to a landfill. The accepts are fed to the wet lap machine, allowing recovered stock to be stored in a convenient form for later reintroduction to the system or for use at another mill.

At some mills, devices such as sidehill or inclined screens may be effective at lower cost. However, the wet lap machine is very useful as a means of providing excess broke storage.

SEGREGATION OF COOLING WATER

Improvements in cooling water segregation in the papermill can result in reductions in water usage. At mills where this control is not currently practiced, modifications are needed to eliminate the discharge of pump seal, calender stack, bearing, and other cooling waters from the sewer. These waters can be collected in a sump and, depending on warm water requirements, either pumped to the mill water system or discharged via a separate thermal sewer. At least 4.2 kl/kkg can be expected to be reduced in most integrated mills.

CLEANER REJECTS TO LANDFILL

Collection and screening of rejects from sources such as pulp cleaners, papermill cleaners, pressure screens, and centrifugal screens eliminate up to 40 percent of the solids to the treatment plant from these sources. The system consists of piping from the reject sources to a collection tank, pump and piping to the screen headbox, a sidehill screen, and rejects dumpster. In the case of remote cleaner reject sources, an accepts tank and pump and piping from the accepts tank to the source for sluice water is required. Savings of 1.5 to 5.0 kg/kkg TSS are possible.

For mills where ample primary clarifier capacity is provided, this measure may not result in significant improvement in overall treatment plant performance. These fiber losses may aid in the dewatering of combined primary/biological sludges.

ADDITION OF FOURTH-STAGE CLEANERS

The addition of a fourth cleaner stage can reduce the flow and solids being discharged from a three stage system by 80 to 90 percent. The pulp stock savings alone can be ample justification for such a system. This control strategy may be an alternative to collection and screening of rejects depending on relative mill operating parameters. Again, if ample primary clarification is provided, this control may not result in significant improvement in overall treatment plant performance.

STEAM PLANT AND UTILITY AREAS

Production process controls that reduce raw waste loads in the steam plant and utility areas include:

- Segregation of cooling waters.
- Installation of lagoons for boiler blowdown and backwash waters.

SEGREGATION OF COOLING WATER

At mills in many subcategories, this control measure is practiced. This control requires modifications to sewers and floor drains to segregate cooling water from the mill process sewer and installation of a warm water storage tank. The sources of cooling water that are to be handled by this system differ at mills in the various subcategories. Generally, they include miscellaneous streams such as pump and bearing cooling water, air compressor cooling water, and major water sources such as turbine and condenser cooling waters. This control is a flow reduction measure, but will also result in energy savings.

ADDITION OF LAGOON(S) FOR BOILER BLOWDOWN AND BACKWASH WATERS

This control can be effective at mills in many of the subcategories. At mills in several subcategories, a separate discharge for these sources is provided or these waters are reused in the process. The boiler blowdown water and the backwash waters can be pumped to a new lagoon, from which they are discharged to receiving waters. This keeps these sources segregated from the wastewater treatment facility and provides sufficient settling time to effectively remove suspended solids. Adjustment of pH is required in some cases. Implementation of this control measure reduces the flow to the wastewater treatment facility. While universally applicable, this measure is widely practiced at mills in only a few subcategories.

RECYCLE OF EFFLUENT

At mills in several secondary fibers and nonintegrated subcategories, fresh water usage is reduced by recycling clarified effluent to the mill for use as hose water and pump seal water. At industrial tissue mills, purchased wastepaper requirements may be reduced through recycle of primary clarifier solids to the process. The major benefit of effluent recycle is flow reduction. Recycle of clarifier solids can yield savings in the cost of raw materials and the cost of handling and disposing of the primary waste solids.

One system to recycle clarified effluent consists of a holding tank, piping from the clarifier to the holding tank, and a pump and piping from the holding tank to existing headers. The solids recycle system consists of a pump with suction from the existing waste solids discharge line and piping to the pulpers. This measure is difficult to implement at mills with severe product quality constraints. It is most likely that this measure can be practiced at mills where industrial and institution grades of tissue paperare produced. Solids recycle occurs primarily at secondary fiber mills.

At some secondary fiber mills, effluent is now recycled. Saveall improvements permit the use of more effluent on machine showers and eliminate the use of fresh water on the machine. Such recycle schemes are not commonly employed in the paperboard from wastepaper, wastepaper-molded products and building paper subcategories. Savealls may serve as a means of recycling both effluent and reclaimed stock in these latter subcategories. At mills in the nonintegrated-tissue papers and nonintegrated-lightweight papers subcategories, a setting basin can be installed to collect discharges from floor drains for reuse of this water rather than fresh water for hoses and seal water. This system can also be employed at mills in the deink and nonintegrated-fine papers subcategories.

CHEMICAL SUBSTITUTION

It is often possible to use different process chemicals to accomplish the same goal. For example, both zinc hydrosulfite and sodium hydrosulfite can be used to bleach mechanical (groundwood) pulps. In recent years, at most groundwood mills, a substitution to the use of sodium hydrosulfite rather than zinc hydrosulfite has been made. This was prompted, at least in part, by the establishment of effluent limitations controlling the discharge of zinc. Rather than invest in costly end-of-pipe treatment, mill management may determine that a less costly and equally effective control option is chemical substitution.

Other opportunities exist to minimize the discharge of toxic and nonconventional pollutants through chemical substitution and are discussed below.

Toxic Pollutants

Slimicide and biocide formulations containing pentachlorophenol are used at mills in the pulp, paper and paperboard industry. Initially, pentachlorophenol was used as a replacement for heavy metal salts, particularly mercuric types. Trichloropenols are also used because of their availability as a by-product from the manufacture of certain herbicides. Formulations containing the following three types of materials are also currently being used:

1. Organo-bromides,
2. Organo-sulfur compounds, and
3. Carbamates.

Substitution to the use of alternate slimicide and biocide formualtions can lead to the virtual elimination of pentachlorophenol and trichlorophenol from these sources.

Nonconventional Pollutants

Ammonia is used as a cooking chemical at eight mills in the semi-chemical, dissolving sulfite pulp, and both papergrade sulfite subcategories. One method for reducing ammonia discharges is the substitution of a different chemical, such as sodium hydroxide for ammonia in the cooking liquor. The quantity of sodium hydroxide required, based on chemical composition and stoichiometry, is 150 kg per kkg of pulp, about three times the required amount of ammonia. The equipment changes necessary to receive and feed a 50 percent solution of NaOH are not likely to be significant.

After conversion to the use of sodium-based chemicals, spent liquor can be incinerated, and sulfur dioxide, sodium sulfate, carbonate, or sulfide can be recovered. These compounds can be sold for use at nearby kraft mills or for other industrial uses; however, markets are not likely to be readily available.

Reducing, smelting furnaces that produce a high-sulfidity, kraft-like green liquor, are not employed at sodium-based sulfite mills. It would be necessary to replace the existing recovery boilers at ammonia-based mills if chemical substitution to a sodium base were employed. Additionally, it is likely that, because the heat value of sodium spent liquor is lower than ammonia spent liquor, evaporator modification may be required if excess capacity does not exist.

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APPENDIX C

EFFLUENT TREATMENT TECHNOLOGIES COMMONLY EMPLOYED BY THE PULP, PAPER, AND PAPERBOARD INDUSTRY

EFFLUENT TREATMENT TECHNOLOGIES COMMONLY EMPLOYED BY THE PULP, PAPER, AND PAPERBOARD INDUSTRY

Many types of wastewater treatment systems are employed at mills in the pulp, paper, and paperboard industry. This appendix describes treatment systems employed by the industry and presents discussions on other applicable effluent treatment technologies based on information derived from an October, 1982 development document for effluent limitations guidelines, new source performance standards and pretreatment standards (1) and other research literature.

PRELIMINARY/PRIMARY TREATMENT

Wastewater must often be screened to remove materials that could seriously damange or clog downstream treatment equipment. Automatically cleaned screens are commonly employed prior to primary treatment and generally represent the preferred practice.

The initial process of removing organic and inorganic solids can be accomplished by sedimenation (with or without flocculants or coagulants), flotation, or filtration. Primary treatment can involve mechanical clarifiers, flotation units, or sedimentation lagoons.

The most widely applied technology for removing solids from pulp, paper and paperboard mill wastewaters is the mechanical clarifier. In the mechanical clarifier, solids are removed by simple sedimentation. Dissolved air flotation (DAF) units have also been applied to remove solids from paper mill effluents. DAF units are somewhat limited in use because of their inability to handle high pollutant concentrations and shock loads. Fine screens, microstrainers, and pressue filters are not commonly used in the industry for solids removal. Adequate fine screening systems cost approximately the same as an equivalent clarifier.

Because of the biodegradable nature of a portion of the settleable solids present in pulp, paper, and paperboard mill wastewaters, clarification can result in some BOD_5 reduction. Typical BOD_5 removal through primary clarification of integrated pulp and paper mill effluent can vary between 10% to 30%. The exact BOD_5 removal depends on the percentage of soluble BOD_5 present in the raw wastewater. Primary clarification can result in significantly higher BOD_5 redictions at nonintegrated mills than at integrated mills. Approximately 50% of the raw wastewater BOD_5 is commonly removed at nonintegrated mills through the application of primary clarification.

Little reduction of fatty acids, resin acids, or their chlorinated derivatives has been observed during primary clarification. This observation suggests that these compounds are not associated with raw wastewater solids measured in TSS test procedures. Polychlorinated biphenyls (PCBs) have been observed to undergo significant reductions through primary treatment. At a deink tissue mill, PCBs were reduced from 25 to 2.5 g/l through primary clarification, while TSS were reduced from 2,020 to 72 mg/l (2).

BIOLOGICAL TREATMENT

Currently, the most common types of biological treatment used in the pulp, paper, and paperboard industry include oxidation basins, aerated stabilization basins, and the activated sludge process or its modifications. Other biological systems that have been used include rotating biological contactors and anaerobic contact filters.

A principal benefit obtained from biological treatment is the reduction of oxygen demand. Biological treatment systems have been designed and operated to achieve 80% to 95% and higher BOD_5 reductions when applied to pulp, paper and paperboard mill effluents.

Due to the fluctuation of influent wastewater characteristics, specific toxic pollutant removal capabilities are not readily measureable unless long-term field sampling is employed. In a laboratory study, specific biodegradability of 6 nonconventional pollutants in pulp, paper, and paperboard mill wastewaters were determined (3). The relative ease with with these 6 compounds were degraded was, in descending order: dehydroabietic acid, primaric acid, tetrachloroguaiacol, monochlorodehydroabietic acid, dichlorodehydroabietic acid, and trichloroguaiacol. Chlorinated bleached plant derivatives were found to be more difficult to degrade than the nonchlorinated wood derivatives.

A another study, an investigation was made of influent and effluent concentrations of toxic and nonconventional pollutants after fullscale biological treatment (4). Removal rates of these pollutants, as derived from published design and treatment data, are shown in Table C-1. The relative removal rates generally agree with those obtained in both studies.

BOD_5 and toxic pollutant removal from bleached kraft wastewater through application of activated sludge treatment and aerated stabilization were investigated in an attempt to establish a relation between pollutant concentration and toxicity. In general, a reduction in BOD_5 to about 45 mg/l was sufficient to achieve detoxification of the waste. Also, a total resin and fatty acid concentration of less than 1 mg/l was necessary to effect detoxification. The correlation between total resin and fatty acid content and toxicity was better than the correlation between BOD_5 and toxicity (5).

OXIDATION BASINS

The first type of biological treatment systems used in the pulp, paper, and paperboard industry were oxidation basins. These are large natural or manmade basins of various depths; natural aeration from the atmosphere is relied on as the primary oxygen source. Additionally, limited oxygen is provided by algal photosynthesis. The amount of oxygen provided through photosynthesis depends on the basin configuration (depth) and its restriction in light penetration. Since oxidation through natural aeration is a relatively low-rate process, large land areas are required to effectively treat high strength wastes. Because of availability of land and a warm climate that enhances bioactivity, most oxidation basins are found in southern states. This technology can be more effective if settleable solids are removed from the wastewater prior to discharge to the basins. Solids can, in certain instances, contribute significantly to the BOD_5 waste loads. In addition, excess settleable solids tend to fill the basins, thus reducing detention time.

Table C-1 CALCULATED TOXIC AND NONCONVENTIONAL POLLUTANT REMOVAL RATES(4)(a)

	Mill (9b) 10-Day ASB	Mill 11(b) 6-Day ASB	Mill 12(c) 3.5-Hour AS	Mill 13(b) 12-Day ASB	Mill 14(b) 7-Day ASB	Mill 15(b) 15-Day ASB
Resin Acids						
Abietic	0.85	0.86	0.3	1.5	1.0	0.45
Dehydroabietic	1.05	2.65	0.6	1.85	1.1	0.72
Isopimaric	0.30	0.37	0.26	1.25	3.0	0.12
Pimaric	0.10	0.14	0.3	0.3	0.1	0.15
Unsaturated Fatty Acids						
Oleic		0.7	0.35	0.55		0.67
Linoleic		2.6	0.30	0.15		0.47
Linolenic		0.4				
Other Acidics						
Epoxysteric Acid						0.03
Dichlorosteric Acid				10.4		0.12
Chlorinated Resin Acids						
Monochlorodehydroabietic		0.10	0.006	0.03		0.01
Dichlorodehydroabietic		0.05	0.019	0.10		0.03
Chlorinated Phenolics						
Trichloroguaiacol		0.03				
Tetrachloroguaiacol		0.02				
Chloroform		2.2	2.1			

(a) Removal rates shown as micrograms removed per milligrams/liter (mg/l) of biomass per day.
(b) Aerated stabilization basin (ASB) biomass assumed to be 200 mg/l.
(c) Activated sludge (AS) biomass reported to be 2,500 mg/l.
NOTE: Blank spaces indicate no data.

Typical design BOD_5 loads range from 56 to 67 kg/ha (kilograms/hectare) of surface area/day (50 to 60 lb/acre/day). Retention times can vary from 20 to 60 days or more. This method of treatment has two principal advantages: a) it can be capable of handling (buffering) accidental discharges of strong wastewater without significant upset and b) it requres no mechanical devices with inherent maintenance problems. Oxidation basins have been used to effectively treat pulp, paper, and paperboard industry wastewaters. Generally, suspended solids are effectively removed in oxidation basins. However, high levels of suspended solids have been noted due to algal carryover. Literature presenting data on the removal of toxic and nonconventional pollutants through application of oxidation basin technology is limited.

AERATED STABILIZATION BASINS (ASBs)

The aerated stabilization basin (ASB) evolved from the necessity of increasing perfromance of existing oxidation basins due to increasing effluent flows and/or more stringent water quality standards. Induced aeration provides a greater supply of oxygen, thus substantially reducing the retention time required to achieve treatment comparable to that attained in an oxidation basin. Nitrogen and phosphorus (nutrients) are usually added prior to the ASB if the wastewater is nutrient deficient. These additions are commonly made in the form of ammonia and phosphoric acid. The longer the retention period of the waste undergoing biological oxidation, the lower the nutrient requirement. The specific detention time used depends upon the characteristics of wastewaters to be treated. Retention times of 8 to 10 days, and sometimes up to 15 days, have been used in order to obtain low levels of BOD_5. The specific detention time used depends on the characteristics of the wastewaters to be treated.

Aeration is normally accomplished using either mechanical surface aerators or diffused air. Oxygen transfer efficiencies under actual operating conditions range from 0.61 to 1.52 kg of oxygen per kilowatt-hour (kwh), or about (1.0 to 2.5 lb of oxygen per horsepower-hour) depending on the type of equipment used, the amount of aeration power per unit volume of equipment used, the amount of aeration power per unit volume, basin configuration, and the biological characteristics of the system (6,7). It is necessary to maintain a dissolved oxygen (DO) level of 0.2 to 0.5 mg/l in the basin to sustain aerobic conditions.

BOD_5 and suspended solids levels, oxygen uptake, and DO levels throughout the basins are related to aerator location and performance and basin configuration. There have been extensive studies of 11 existing aerated stabilization basins that have led to development of design criteria to aid in the design of future basins (8).

Some solids accumulate in the bottom of ASB's that can be removed with periodic dredging. Solids accumulation diminishes as the detention time and degree of mixing within the basin increases. At some mills, a quiescent zone, settling basin, or clarifier is used to improve effluent clarity and reduce suspended solids.

In an evaluation of the efficiency of an ASB treating unbleached kraft waste, average reductions of 87% BOD_5 and 96% total resin acids were achieved (9). Dehydroabietic acid was the only resin acid identified in the treated effluent; pimaric, isopimaric and abietic acids tended to concentrate in the foam from the effluent.

Pilot-scale ASB treatment of bleached kraft wastewater was evaluated over a 5 month period (5). Two basins, one with a 5 day and one with a 3 day hydraulic detention time, were studied with and without surge equalization. The raw wastewater BOD_5 varied from 108 mg/l to 509 mg/l, while total resin and fatty acid concentrations range from 2 to 9 mg/l. Mean BOD_5 removals with surge equalization were 85% for the 5 day basin and 77% for the 3 day basin. Mean effluent BOD_5 levels with surge equalization were 40 mg/l for the 5 day basin and 59 mg/l for the 3 day basin. Mean effluent BOD_5 values for the 5 day and 3 day basins without equalization were 51 mg/l and 67 mg/l, respectively. Since the surge capacity of an aerated stabilization basin is relative to hydraulic detention time, the 8 to 10 day basins which are commonly employed in the pulp, paper, and paperboard industry in the United States could have a higher capacity for shock loading than those discussed here.

Aerated stabilization basins provide a high degree of BOD_5 reduction. ASB capital and operating costs may be lower than those for the activated sludge process. The treatment efficiency is not as dependent on ambient air tempeature as with oxidation basins; however, efficiency can be more dependent on ambient air tempeature for ASBs than for higher rate processes, i.e., activated sludge.

ACTIVATED SLUDGE PROCESS

The activated sludge process is a high-rate biological wastewater treatment process. The biological mass (biomass) grown in the aeration basins is settled in a secondary clarifier and varying amounts of this biomass are returned to the aeration basins, building up a large concentration of active biological material. It is common to maintain 2,000 to 5,000 mg/l of active biological solids in the aeration basin section of the activated sludge system compared to the 50 to 200 mg/l common to aeration stabilization basins. Loadings in excess of 1.6 kg of BOD_5 per cubic meter of aeration capacity per day are sometimes used, allowing for relatively small aeration basins.

The characteristically short detention times tend to make the activated sludge process more susceptible to upset due to shock loads. When the process is disrupted, it may require several days for biological activity to return to normal. Particular operator attention is required to avoid such shock loadings at mills where this process is employed. The necessity for strict operator attention can be avoided through provision of sufficient equalization to minimize the effects of shock loadings.

Compared with aerated stabilization basins, the activated sludge process has less shock load tolerance, greater solids handling requirements, and higher costs. However, the activated sludge process requires less land than ASBs. Thus, it may be preferred in cases where sufficient land for ASB installation is either unavailable or too expensive.

The activated sludge process is very flexible and can be adapted to many waste treatment situations. The activated sludge process has many modifications that can be selected as most appropriate. Various types of activated sludge processes that have been applied to treat pulp, paper, and paperboard wastewaters include (10):

- Conventional
- Complete-mix
- Tapered aeration
- Step aeration
- Modified aeration
- Contact stabilization
- Extended aeration
- Oxidation ditch

- Pure oxygen
- Zurn-Attisholz process

In the conventional activated sludge process, both influent wastewater and recycled sludge enter the aeration basin at the head end and are aerated for a period of about 4 to 8 hours or more. Mechanical surface aerators similar to those used in aerated stabilization basins are used; the use of diffused air is becoming more common. Normally, the oxygen demand decreases as the mixed liquor travels the basin length. The mixed liquor is settled and the activated sludge is generally returned at a rate of approximately 25% to 50% of the influent flow rate.

In the complete-mix activated sludge process, influent wastewater and recycled sludge enter the aeration basin at several points along the length of the basin. The mixed liquor is aerated at a constant rate as it passes from the central channel to effluent channels at both sides of the basin. The contents of the basin are completely mixed and the oxygen demand remains uniform throughout. The aeration period is from 3 to 5 hours or more, and the activated sludge is returned at a typical rate of 25% to 100% of influent flow rate.

The tapered-aeration process is a modification of the conventional process with the primary difference being the amount of air supplied. At the head of the basin, where wastewater returned sludge come into contact, more oxygen is required. As the mixed liquor traverses the aeration basin, the oxygen demand decreases as aeration is decreased. Since the oxygen supply is decreased with the oxygen demand, a lower overall oxygen requirement can be achieved.

The step-aeration process also is a modification of the conventional activated sludge process. In this modification, the wastewater is introduced at several points in a compartmentized basin while the returned activated sludge is introduced at the head of the basin. Each compartment of the basin is a separate step with the several steps linked together in series. Aeration can be of the diffused or mechanical type and is constant as the mixed liquor moves through the tank in a plug-flow fashion. The oxygen demand is more uniformly spread over the length of the basin than in the conventional activated sludge process, resulting in better utilization of the oxygen supply. The aeration period is typically between 3 and 5 hours and the activated sludge is returned at a typical rate of 25% to 75% of influent flow rate.

The contact-stabilization process takes advantage of the absorptive properties of activated sludge through operation in two stages. The first is the absorptive phase in which most of the colloidal, finely suspended, and dissolved organics are absorbed in the activated sludge in a contact basin. The wastewater and return stabilized sludge enter at the head of the contact basin, are aerated for a period of 30 to 60 minutes or more, and settled in a conventional clarifier. The second stage is the oxidation phase, in which the absorbed organics are metabolically assimilated providing energy and producing new cells. In this stage, the settled solids from the absorptive stage are aerated for a period of from 3 to 6 hours or more in a stabilization basin. A portion of the solids are wasted to maintain a constant mixed liquor volatile suspended solids (MLVSS) concentration to the stabilization basin. Contact stabilization has been applied successfully at several facilities to treat kraft mill wastewaters.

The extended-aeration process is a complete-mix activated sludge process in which the aeration period is relatively long (18 to 36 hours or more) and the organic loading relatively low. Because of these conditions, the process is very stable and can accept intermittent loads with minimal or no upset. The solids settled in the clarifiers are recirculated to the influent of the aeration basins. Through this process, a mass of biological solids are built up in the aeration basin. This biomass assists in achieving high treatment efficiencies through removal of dissolved organic matter in the wastewater by oxidation. Excess secondary solids, if present, are wasted from the process. Oxygen may be provided by either mechanical or diffused aeration. This process has been applied successfully throughout the pulp, paper, and paperboard industry. In northern climates, where temperatures can impact the system performance, the extended-aeration process offers the stability of an ASB system and the high treatment efficiency of the activated sludge process.

The oxidation ditch activated sludge process is an extended-aeration process in which aeration and circulation are provided by brush rotors placed across a race track-shaped basin. The wastewater enters the ditch at one end, is aerated, and circulates at about 0.3 to 0.6 meters per second (1 to 2 fps). Operation can be intermittent, in which case clarification takes place in the ditch, or continuous in which case a separate clarifier and piping for recycling of settled solids are provided.

Two pilot-scale activated sludge systems (8-hour and 24-hour detention) were operated with and without surge equalization over a 5 month period (5). Raw wastewater BOD_5 varied from 108 to 509 mg/l. Total resin and fatty acid concentrations in the raw wastewater ranged from 2 to 9 mg/l. Mean BOD_5 removals for the 8-hour and 24-hour activated sludge systems with a 12-hour surge equalization basin achieved an average of 72% to 76% BOD_5 removal, respectively. Effluent BOD_5 concentrations for the 24-hour system ranged from 5 mg/l to 263 mg/l, with a mean of 59 mg/l. Final effluent BOD_5 concentrations for the 8-hour system range from 14 to 270 mg/l with a mean of 70 mg/l.

The 24-hour activated sludge system, when operated without equalization, was subjected to more vigorous mixing plus the addition of 10 mg/l alum. Under these conditions, an average of 90% BOD_5 removal was obtained. The 8-hour activated sludge system, when operated without surge equalization, was also subjected to more vigorous mixing with no addition of alum. Under these conditions, an average of 84% BOD_5 removal was obtained. It was concluded that equalization did not affect BOD_5 removal efficiency.

The pure oxygen activated sludge process uses oxygen, rather than air, to stimulate biological activity. This scheme allows for a lesser detention time and a lower aeration power requirement than for the conventional activated sludge process; however, additional power is required for oxygen generation which may result in a net increased power requirement. Waste secondary solids volumes that must be dewatered and disposed of are similar to those produced by air activated sludge systems. Final effluent BOD_5 concentrations on the order of 15 to 30 mg/l have been achieved with the oxygen activated sludge process when applied to unbleached kraft wastes, with effluent TSS after clarification generally in the range of 40 to 60 mg/l.

A sulfite-newsprint effluent was treated using an oxygen activated sludge pilot plant facility over an 11 month period (11). BOD_5 reductions during this time were over 90%. Final BOD_5 and TSS concentrations ranged from 23 to 42 mg/l and 61 to 111 mg/l, respectively. Total resin acids before and after oxygen activated sludge treatment were 25 and 6 mg/l, respectively. Ammonia was found at levels on the order of 50 mg/l. The treated effluent was air stripped, which reduced the ammonia concentration to less than 1 mg/l and the total resin acid concentration to 1 mg/l.

Two pure oxygen activated sludge systems were also studied; (4) one treating integrated bleached kraft wastewater and the other treating unbleached kraft pulp mill wastewater. Both significantly reduced all identified pollutants. The pollutants evaluated included resin and fatty acids, their chlorinated derivatives, and chloroform. The first system incorporated an oxygen activated sludge basin with hydraulic detention of 190 minutes and a sludge recycle rate of 35%. The pH was maintained between 6.2 and 7.5. It was determined that 43% to 92% of identified pollutants were removed, with the chlorinated resin acids exhibiting relatively low removal efficiencies.

The second oxygen activated sluge system was operated at a detention time of 3.7 hours and a mixed liquor suspended solids (MLSS) concentration of 2,500 mg/l. Bench-scale alum/polyelectrolyte coagulation followed. The effluent was adjusted to a pH of 5 with alum; 1 mg/l of polyelectrolyte was added. Essentially complete removal of all identified resin and fatty acids was obtained. It should also be noted that initial concentrations in the raw waste were relatively low. Since no data were reported for the oxygen activated sludge system without chemically assisted clarification, the relative effects of each of the two processes on removal efficiencies could not be determined.

The Zurn/Attisholz (Z/A) process is a two-stage activated sludge system. The first stage operates at a DO of less than 1.0 mg/l; the DO level in the second stage is maintained at 4 to mg/l. Nutrient and power requirements for the two-stage system are similar to those for the conventional activated sludge process. A total Z/A detention time of four hours may be required to achieve BOD_5 and TSS reductions comparable to activated sludge and aerated stabilization basin systems.

Seven full-scale Z/A systems are currently in use at pulp, paper, and paperboard mills in the U.S. These installations treat wastewaters from the following types of manufacturing:

Deink (Fine or Tissue)	(5 mills)
Papergrade Sulfite	(1 mill)
Groundwood-Fine Papers	(1 mill)

At most of the mills were the Z/A process is used, final effluent BOD_5 and TSS concentrations in the range of 20 to 25 mg/l are attained (12). At one mill, BOD_5 and TSS levels in the range of 5 to 10 mg/l are attained. At another mill 96% BOD_5 and 99% TSS reductions are attained using the Z/A process (13).

ROTATING BIOLOGICAL CONTACTOR (RBC)

This system involves a series of discs on a shaft supported above a basin containing wastewater. The discs are 40% to 50% submerged in the wastewater and are slowly rotated; a biological slime grows on the disc surfaces. Closely spaced discs with a diameter of 3.7 meters (12 ft) mounted on a 7.6 meter (25 ft) shaft can result in 9,300 square meters (100,000 sq ft) of surface area.

Pilot-scale evaluations of an RBC system treating bleached kraft wastewater with an averge influent BOD_5 concentration of 235 mg/l have resulted in substantial BOD_5 reductions (14). The degree of removal is inversely related to the hydraulic loading rate. Secondary waste solids production ranged from 0.3 to 0.5 kg of solids per kg of BOD_5 removed (0.3 to 0.5 lb of solids per lb of BOD_5 removed).

Two pilot plant evaluations reported final effluent BOD_5 of 59 mg/l for an integrated kraft mill, 65 mg/l for a board mill, and 338 mg/l for magnesium-based sulfite mill (15). Raw wastewater BOD_5 levels for these mills were 290 mg/l, 285 mg/l, and 1,300 mg/l, respectively. No TSS data were reported. This pilot plant work indicated good BOD_5 reduction capabilities. However, to date, mill-scale systems in the U.S. treating pulp mill wastewater have encountered operating difficulties (1).

ANAEROBIC CONTACT FILTER

This process involves the use of a basin filled with crushed rock or other media. Wastewater is passed through the media at a temperature of 32°C to 35°C under anaerobic conditions; detention times on the order of three days are common. Steam stripping, nutrient addition, neutralization, and dilution of waste liquor with wash water may be required as pretreatment.

A laboratory study of this process showed that 80% to 88% BOD_5 removal from sulfite wastewaters have been achieved (16). The major advantage of the process was found to be a low solids production rate of 0.08 kg of solids per kg of BOD_5 removed (0.08 pounds of solids per pound of BOD_5 removed) (this is because methane gas, rather than biological solids, is the by-product of anaerobic digestion). The study concluded that the cost for the anaerobic process was approximately the same as that for aerated stabilization.

AMMONIA REMOVAL THROUGH NITRIFICATION

One method of ammonia removal is through single-stage nitrification in a biological treatment system. Nitrification is the process where specific bacteria, Nitrosomonas and Nitrobacter, oxidize ammonia to nitrite nitrogen and then to nitrate nitrogen.

Biological treatment systems presently employed at mills in the pulp, paper, and paperboard industry are generally designed and operated for oxidation of organic material, i.e., BOD_5 reduction. It is possible, however, to design and operate these systems to accomplish BOD_5 and ammonia reduction in a single step or in a series of steps. Nitrifying organisms exhibit a very slow growth rate in comparison to organic assimilation and are very sensitive to environmental conditions and growth inhibitors, such as toxic organic wastes and heavy metals. Growth rates and, thus, nitrification rates are profoundly influences by such environmental factors as pH, temperature, and dissolved oxygen concentrations. Since the nitrifiers are autotrophic, inorganic carbon sources (such as carbon dioxide, carbonates, and bicarbonate) have a large influence on microbial growth rates (17).

Aerobic nitrifiers require relatively large quantities of molecular oxygen to complete the oxidation of ammonia. The theoretical oxygen requirements, based on the biochemical equations of nitrification, were determined to be 4.57 kg of O_2 required/kg of ammonia nitrified (4.57 lb of O_2 required/lb of ammonia nitrified). Generally, this oxygen demand may be satisified by atmospheric molecular oxygen furnished through conventional aeration techniques. However, since the nitrifiers are autotrophic and obtain their carbon requirements from such compounds as carbon dioxide and bicarbonates, the oxygen contained in these compounds may also be available for metabolism. Thus, depending on the alkalinity of the wastewater, the actual oxygen which must be furnished by aeration equipment may be lower than the theoretical 4.57 ratio. Discounting the ammonia required for BOD_5 removal, the nitrifiers will also utilize a fraction of the available nitrogen for synthesis of cellular components. This ammonia demand is estimated to be equivalent to 0.7 to 0.9 oxygen equivalents; therefore, the theoretical oxygen ratio of 4.57 would be reduced to about 3.9 kg of O_2/kg of ammonia nitrified (18).

Since the nitrifiers have slower growth rates, a biological system designed for nitrification requires a longer detention time and longer sludge age. Insufficient nitrification will result unless the sludge wastage rate is lowered to accommodate the nitrifier requirements. Therefore, the wasteage rate is usually controlled to maintain a sufficient sludge age in the system to accomplish nitrification. Published data for municipal wastes indicate that a sludge age greater than 4 days in the activated sludge process is adequate for 90% nitrification 20°C (18). Laboratory experiments conducted on pulp and paper wastewaters (weak black liquor) with influent ammonia and BOD_5 concentrations of 264 mg/l and 511 mg/l indicate that a sludge of approximately 14 days is required for conversion of 90% of the ammonia to nitrate (17).

In the absence of severe inhibitors, a single-stage activated sludge system can be properly designed to achieve BOD_5 removal and nitrification in a single aeration basin. A 90% ammonia removal can be achieved through nitrification provided that proper operating conditions are maintained (1). In low strength wastes, ammonia removal to levels of less than 10 mg/l is achievable depending on the variability of the influent ammonia concentration (18).

Temperature, pH, and dissolved oxygen levels are parameters having interrelated effects on the nitrification process. This sensitivity and the difficulty in maintaining optimum environmental conditions can be overcome through treatment system design and operation. To offset the decrease in the nitrification rate that can occur if optimum conditions are not maintained, longer aeration basin detention times and longer sludge ages can be employed and maintained. Additionally, provisions can be made to (a) neutralize the effluent to maintain a proper pH, and (b) heat or cool the effluent and/or cover the aeration basins to maintain proper temperature.

CHEMICALLY ASSISTED CLARIFICATION

Dissolved and colloidal particles in treated effluents are not readily removed by simple settling. Colloidal particles can be agglomerated by the addition of chemical coagulants. Coagulants in common use include lime, alum, ferric chloride, ferric sulfate, and magnesia.

One of the most efficient methods of pulp and paper mill effluent flocculation is a solids-contact type clarifier. A theory for the operation of solids-contact clarifiers considers that integrated role as flocculators, fluidized beds, and phase separators (19). The criterion for good performance is the dimensionless product of velocity gradient, time, and floc concentration. Model floc blanket studies can be meaningful for full-scale operation provided that the concentration of floc in the blanket and blanket depth are the same in both model and prototype.

Upon floc formation, settling is accomplished in a quiescent zone. The clarification process results in waste solids that must be collected, dewatered, and disposed. The quantity, settleability, and dewaterability of the waste solids depend largely on the coagulant employed. In some cases the coagulant can be recovered from the waste solids and reused.

FULL-SCALE SYSTEM CASE STUDIES

Several full-scale, chemically assisted clarification systems have been constructed in the pulp, paper, and paperboard industry and in other industrial point source categories. Data on the capability of full-scale systems to remove conventional and nonconventional pollutants are presented below.

Conventional Pollutants

Recent experience with full-scale alum-assisted clarification of biologically-treated kraft mill effluent suggest that final effluent levels of 15 mg/l each of BOD_5 and TSS can be achieved. The desired alum dosage to attain these levels can be expected to vary depending on the chemistry of the wastewater to be treated. The optimum chemical dosage is dependent on pH.

Chemical clarification following activated sluge is currently being employed at a ground-wood (chemi-mechanical) mill (1). Alum is added at a dosage of about 15 mg/l to bring the pH to an optimum level of 6.1. Polyelectrolyte is also added at a rate of 0.9 to 1.0 mg/l to improve flocculation. Neutralization using NaOH is practiced prior to final discharge to being the pH within acceptable discharge limits. The chemical/biological solids are recycled through the activated sludge system. Average results for 12 months of sampling data shows a raw wastewater to final effluent BOD_5 reduction of 426 mg/l to 12 mg/l and TSS reduction of 186 mg/l to 12 mg/l. Data obtained over 22 months shows average final effluent BOD_5 and TSS concentrations of 13 and 11 mg/l, respectively (20).

Testing at a chemically assisted clarification system treating effluent from an aerated stabilization basin at a Northeast bleached kraft mill showed that the alum dosage could be reduced significantly by the addition of acid for pH control, while still attaining substantial TSS removal (21). It was shown that total alkalinity, a measure of a system's buffering capacity, was a reliable indication of wastewater variations and treatability, and that there is a direct relationship bewteen total alkalinity and alum demand. High alkalinity (up to 500 mg/l) caused by the discharge of black liquor or lime mud results in high alum demands. Therefore, a substantial portion of alum dosage can be used as an expensive and ineffective means of reducing alkalinity (pH) to the effective pH point (5-6) for optimum coagulation. The use of acid to assist in pH optimization can mean substantial cost savings and reduction in the alum dosage rate required to effect coagulation. In one instance, use of concentrated sulfuric acid for pH reduction reduced alum demand by 45%. Acid addition was also effective in reducing alum dosage for wastewaters with a low alkalinity (approximately 175 mg/l).

A cellulose mill located on the shore of Lake Baikal in the USSR produced 200,000 kkg of tire cord cellulose and 11,000 kkg of kraft pulp per year. Average water usage was 1,000 kl/kkg. The mill had strong and weak wastewater collection and treatment systems. The average BOD_5 for the weak wastewater system was 100 mg/l, while the strong wastewater BOD_5 was 400 mg/l. Only 20% of the total wastewater flow as included in the strong wastewater system. Each stream received preliminary treatment consisting of neutralization to pH 7.0 nutrient addition, and aerated equalization. Effluent from equalization was discharged to separate aeration and clarification basins. These basins provided biological treatment using a conventional activated sludge operation. Aeration was followed by secondary clarification. Suspended solids were settled and 50% of the sludge was returned to the aeration process. Waste sludge was discharged to lagoons. The separate streams were combined after clarification an were treated for color and suspended solids removal in reactor clarifiers with 250 to 300 mg/l of alum and 1 to 2 mg/l of polyacrylamide flocculant, a nonionic polymer. The clarifiers had an overflow rate of approximately 20.4 m^3 per day/m^2(22). Chemical clarification overflow was discharged to a sand filtration system. The sand beds were 2.9 m (9.6 ft) deep with the medial arranged in 5 layers. The sand size varied from 1.3 mm (0.05 in) at the top to 33 mm (1.3 in) at the bottom. The filter was loaed at 0.11 m^3 per min/sq m (2.7 gpm/ft^2). Effluent from sand filtration flowed to a settling basin and then to an aeration basin; both basins were operated in series and provided a 7-hour detention time (23).

The effluent quality attained was as follows:

Parameter	Raw Waste	Final Effluent
BOD_5 (mg/l)	300	2
Suspended Solids (mg/l)	60	5
pH	-	6.8-7.0

Nonconventional Pollutants

The development of coagulation processes for color removal has been traced by many investigators (1). Investigators concluded that lime precipitation was a coagulation process for color removal which afforded the possibility of chemical recovery utilizing existing mill equipment. Based on the results of this early work, research continued towards development of a lime precipitation process. The overriding problem in this work continued to be the difficulty of dewatering the lime-organic sludge.

Continuing efforts to improve the dewatering of the lime sludge led to consideration of using large dosages of lime for color reduction. It was believed that a large quantity of rapidly draining materials would reduce the effect of the organic matter on dewatering. This thinking lead to the development and patenting of the "massive lime" process by the National Council for air and Stream Improvement. In this process, the mill's total process lime is slaked and reacted with a highly colored effluent stream, usually the caustic extraction effluent. The lime sludge is then settled, dewatered, and used for causticizing green liquor. During the causticizing process, the color bodies are dissolved in the white liquor and eventually burned in the recovery furnace.

The first installation of a massive lime color system was operated at a mill in Springhill, LA (1). The 33.4 liter per sec (530 gpm) demonstration plant was used to treat the bleach plant caustic extraction and unbleached stock decker wastewater. These streams contributed 60% to 75% of total mill color. In the process, the lime slurry dosage was 20, 000 mg/l.

The demonstration plant at Springhill was first tested using 100% bleach plant caustic extraction effluent. Various amounts of unbleached decker effluent were then added until 100% decker effluent was treated. Color removal ranged from 90% to 97% with an average of 94% to 95%. Organic carbon removal ranged from 55% to 75% and generally increased with higher colored effluent. BOD_5 removals of 25% to 45% were reported with lower values found during treatment of most highly-colored effluent. The net effect of the treatment process was estimated as a 72% reduction of total mill color.

The massive lime process, as developed, required lime dosages of approximately 20,000 mg/l. Because of this, only a relatively small effluent stream could be treated with the quantity of lime used for causticizing green liquor. Additionally, this process required modifications to the recovery system. These restriction led to the development of an alternative process employing "minimum lime" treatment. Lime dosages of 1,000 to 2,000 mg/l are common to this process. Two systems treating unbleached kraft and NSSC effluents are known to be operating. Color levels of 1,200 to 2,000 color units are reported to 80% to 90% removed with lime dosages of 1,000 to 1,500 mg/l. Lime dosages of 1,500 to 3,000 mg/l were used to remove 90% of color load that range from 8,000 to 10,000 color units (1).

PILOT AND LABORATORY-SCALE SYSTEM CASE STUDIES

Several laboratory and pilot-scale studies of the application of chemically assisted clarification to treat pulp, paper, and paperboard wastewaters have been conducted. Available data on the capability of this technology to remove conventional and nonconventional pollutants based on laboratory and pilot-scale studies are presented below.

Conventional Pollutants

At an integrated unbleached kraft mill, effluent treatment consisted of primary clarification and aerated stabilization followed by a holding pond. The average suspended solids in the discharge from the holding pond were 65 mg/l for the period of January 1, 1973 to December 31, 1974. In tests on this wastewater, 70 to 100 mg/l of alum at a pH of 4.5 provided optimum coagulation (24). Three alum dosages were tested. At the optimum dosages, the removals after 24-hours of settling ranged from 83% to 86%. Influent TSS of the sample tested was 78 mg/l. Effluent TSS concentrations ranged from 11 to 13 mg/l.

In a laboratory study, alum, ferric chloride, and lime in combination with 5 polymers were evluated in further treatment of biological effluents from 4 pulp and paper mills (25). Of the 3 chemical coagulants, it was reported that alum provided the most consistent flocculation at minimum dosages, while lime was the least effective of the three. However, the study provided inconclusive results in determining the optimum chemical to be used or the optimum chemical dosage for removal of TSS from biologically-treated effluents.

For bleached and unbleached kraft wastewaters, significant removal of suspended solids has been found to occur at alum dosages in the range of 100 to 350 mg/l (1). For wastewaters discharged in the manufacture of dissolving sulfite pulp, effluent BOD_5 and TSS removal required dosage rates of 250 mg/l; however dosages required to achieve effluent TSS concentrations on the order of 15 mg/l would be in the range of 250 to 500 mg/l. Jar test data for chemical pulping subcategories indicate that alum dosages in the range of 100 to 700 mg/l will effect significant removals of TSS. The average dosage rate for all chemical pulping wastewaters was 282 mg/l. For the groundwood, deink, and nonintegrated-fine papers subcategories, dosages in the range of 100 to 200 mg/l will significantly reduce effluent TSS (1).

Toxic and Nonconventional Pollutants

Biologically-treated effluent from a kraft mill was further treated using alum precipitation technology on a laboratory-scale (4). Existing full-scale treatment at the mill consisted of a primary clarifier, an aerated stabilization basin, and a polishing pond. Twenty-four hours composite samples of the polishing pond effluent were taken on three separate days. The samples were adjusted to a pH of 4.6 with alum; 4 drops of polymer per liter of sample were added. The results are summarized below:

	Polishing Pond Effluent Range (mg/l)	Alum-Treated Effluent Range (mg/l)
Total Resin and Fatty Acids	2.82-3.75	Undetected
Total Chlorinated Derivatives	0.43-0.45	Undetected-0.04
Chloroform	0.025-0.032	0.018-0.022
BOD_5	43.0-51.0	0-14.0

Other researchers investigating chemically assisted clarification technology reported on the use of ferric sulfate, lime, and alum to reduce effluent color at two bleached kraft mills and one unbleached kraft paperboard mill (26,27). Their results, as shown in Table C-2 provide both an optimum pH and optimum dosage for each case. All three coagulants were able to achieve a reduction in color from 1,000 to 3,000 platinum-cobalt (Pt-Co) units to 125 to 300 Pt-Co units. Note that the dosage required for color reduction is higher than that generally applied for BOD_5 and TSS reduction only.

It was concluded that ferric sulfate used for color removal of pulp, paper, and paperboard mill wastewaters can be attractive alternative to lime treatment. The required optimum dosage of ferric sulfate was 25% to 33% that of the optimum lime dosage. In addition, the effluent quality which results from the use of ferric sulfate was better than that resulting from lime. Lime treatment results in a high pH and a great deal of calcium in solution. Common practice is to use an additional treatment step, recarbonation, which reduces the pH prior to biological treatment and allows for recovery of calcium as $CaCO_3$.

The use of ferric sulfate and alum prior to biological treatment does not require recarbonation and may not require neutralization. Another study concluded that if the alum treated kraft mill effluent pH did not fall below 5.8, neutralization was not needed prior to biological treatment (1).

Table C-2 COLOR REDUCTIONS ACHIEVED AFTER APPLICATION OF CHEMICALLY ASSISTED CLARIFICATION WITH FERRIC SULFATE, ALUM AND LIME (26,27)

	Optimum Dosage (mg/l)			Color Reduction (%)			Final Color Value (Pt-Co Units[1])			Optimum pH		
	$FeSO_4$	Alum	Lime	$FeSO_4$	Alum	Lime	$FeSO_4$	Alum	Lime	$FeSO_4$	Alum	Lime
Bleached Kraft	500	400	1,500	92	92	92	250	200	300	3.5-4.5	4-5	12-12.5
Bleached Kraft	275	250	1,000	91	93	85	125	100	200	3.5-4.5	4-5	12-12.5
Unbleached Kraft Paperboard	250	250	1,000	95	91	85	150	100	150	4.5-5.5	5-6	12-12.5

[1] Platinum-Cobalt Units

Laboratory studies on color reduction with a combined ferric chloride and lime treatment system sought to establish conditions for improving the lime treatment systems by using multivalent ions with the lime for color precipitation (28). Earlier investigations of the lime precipitation treatment system removal demonstrated 85% to 90% removal of color; it was determined that the remaining color bodies had an apparent average molecular weight of less than 400. Preliminary studies with multivalent ions and lime showed almost total color removal.

Tests were run in the laboratory on kraft mill decker filtrate and caustic extraction discharge. Various salts such as barium chloride, ferric chloride, magnesium hydroxide, and zinc chloride were used in the initial experiments. Based on data from these intitial experiments, ferric chloride was selected for further analysis. In general, it was determined that trivalent ions are more effective color-removing agents than divalent ions (28).

Twenty-four experiments were run using ferric chloride and/or lime at various concentrations. Color removal up to 98.7% was attained and it was concluded that a synergistic effect between lime and ferric chloride existed (28).

Laboratory-scale studies were conducted on the decolorization of biologically-treated pulp and paper mill effluents through the addition of lime and lime-magnesia using effluents from three kraft mills, one sulfite mill, and one NSSC mill (29). All except one of the kraft mill effluents had been treated in a biological system before chemical treatment. Separate testing with lime and magnesia showed that, with the addition of 1,000 mg/l of lime, approximately 90% of the color was removed. Magnesia alone proved to be ineffective at moderate doses; 4,000 mg/l were required to obtain approximately 50% color reduction. Therefore, it was concluded that the use of magnesia alone could not be justified.

The use of magnesium hydroxide in combination with lime was highly effective. The magnesium was added as a soluble salt prior to the lime slurry. A dosage of 50 to 100 mg/l magnesia prior to the additon of 500 mg/l of lime gave the same color removal as the addition of 1,000 mg/l of lime alone. Additionally, sludge production was less with the lime-magnesia process. Recovery techniques were suggested, but none were investigated in connection with this study. This would indicate that additional testing would have to be done to prove the feasibility of this lime-magnesia recovery process before attempting it on a larger scale. An evaluation concluded that the system is costly, but the benefits might favor its use.

FILTRATION

This process refers to granular bed (rather than membrane) filtration. The granular material may be sand, or coal, diatomaceous earth, and/or garnet in combination with sand. The various media, grain sizes, and bed depths may be varied for optimal results. It is common to vary grain sizes, with the larger sizes at the top of the filter bed, to improve TSS removal and to extend filter run time between backwashings. The addition of a proper chemical flocculant prior to filtration can further improve performance.

Filtration technology was evaluated on 9 pulp, paper, and paperboard and other industrial facilities where filtration was used (20). At those facilities where chemical coagulants were not utilized, final effluent levels of TSS ranging from 5.9 to 35 mg/l were achieved across the filter; TSS reductions ranged from 45% to 79%. Those where coagulants were used prior to filtration achieved final effluent TSS levels ranging from 5.0 to 27.5 mg/l with removals of 52% to 85%. At the paperboard mill employing single medium sand filtration without chemical addition, an effluent TSS level of 7 mg/l was attained.

At a midwestern mill where paperboard is produced from wastepaper, effluent is treated in an aerated stabilization basin followed by a 3-layer, pressure sand filter, without the use of coagulants. The system was designed to remove 50% of the biological solids but, in practice, removes only 30% to 40% (1).

ACTIVATED CARBON ADSORPTION

Currently, there are two basic approaches for the use of activated carbon: a) use in a tertiary sequence following primary and biological processes and b) use in a "physical-chemical" treatment in which raw wastewater is treated in a primary clarifier with or without chemical coagulants prior to carbon adsorption.

The tertiary approach involves the reduction of biodegradable organics prior to discharge to the carbon system. This provides for longer carbon life. In a physical-chemical treatment mode, biodegradable and refractory organics are removed solely through adsorption on the activated carbon. Activated carbon can achieve high removals of dissolved and colloidal pollutants in water and wastewater. When applied to a well-treated biological effluent, it is capable of reducing BOD_5 to less than 2.0 mg/l (30).

The primary means of removal is surface adsorption. The key to the carbon adsorption process is the extremely large surface areas of the carbon, typically 3.54 to 9.92 m^2/g (31).

Activated carbon will not remove certain low molecular weight organic substances, particularly methanol, a common constituent of pulping effluents. Additionally, carbon columns do a relatively poor job of removing turbidity and associated organic matter. Some highly polar organic molecules such as carbohydrates also will not be removed through the application of activated carbon treatment. However, most of these materials are biodegradable and, therefore, should not be present in appreciable quantities in a well bio-oxidized effluent.

Activated carbon may be employed in several forms including: a) granular, b) powdered, and c) fine. The utlimate adsorption capacities for each may be similar. The optimal carbon form for a given application should be determined by laboratory and/or pilot testing. Each of the three forms of carbon listed above is discussed below.

Granular Activated Carbon

Granular activated carbon (GAC) treatment usually consists of one or more trains of carbon columns or beds, including one or more columns per train. The flow scheme may be down through a column, up through a packed carbon bed, or up through an expanded carbon bed. The optimum column configuration, flow scheme, and carbon requirements can best be determined through field testing.

It can be economically advantageous in many granular activated carbon applications to regenerate the exhausted carbon. Controlled heating in a multiple-hearth furnace is currently the best procedure for removing adsorbed organics from activated carbon. Typically, the regeneration sequence is as follows:

- Pump exhausted carbon in a water slurry to the regeneration system for dewatering.
- After dewatering feed the carbon to a furnace at 816° to 927°C (1,500° to 1,700°F) where the adsorbed organic and other impurities are oxidized and volatized.

- Quench the regenerated carbon in water.
- Wash the carbon to remove fines; hydraulically transport the regenerated carbon to storage.
- Scrub the furnace off-gases and return the scrubber water for treatment.

Powdered Activated Carbon

A recent variation of activated carbon technology involves the addition of powdered activated carbon to biological treatment systems. The adsorbant quality of carbon, which has been known for many years, aids in the removal of organic materials in the biological treatment process. This treatment technique also enhances color removal, clarification, system stability, and BOD_5 and COD removal. Results of pilot testing indicate that this type of treatment, when used as a part of the activated sludge process, is a viable alternative to granular carbon systems (1,32). Pilot tests have also shown that powdered activated carbon can be used successfully with rotating biological contactors.

Fine Activated Carbon

This process is a multi-stage, countercurrent, agitated system with a continuous transfer of both carbon and liquid. One of the major aspects of the fine activated carbon system is the use of an intermediate-size carbon in an attempt to combine the advantages of both powdered and granular carbon while minimizing their limitations. Equipment size and carbon inventory are decreased due to the increased adsorption rate of the intermediate-size carbon.

FOAM SEPARATION

Foam separation techniques have been evaluated to determine their effectiveness in treating surface active substances; i.e., resin acids, in pulp, paper, and paperboard mill wastewaters. This process involves physical removal of surface active substances through foam generation. In this process, fine air bubbles are introduced into a basin or structure containing the effluent. The air bubbles cause generation of foam in which the surface active compounds are concentrated. Jet air dispersion has been found to be the most efficient technique for foam generation when compared to turbine and helical generation systems (33).

A bleached kraft whole mill effluent was analyzed for total resin acid content before and after treatment in a pilot-scale foam separation unit (34). Two mill effluents were treated in a 2-hour detention time foam separation pilot unit. The resin acids content in all cases was reduced by between 46% and 66%. The range of total resin acid content in the influents and effluents was 2.6 to 5.1 mg/l and 0.1 to 1.0 mg/l, respectively.

MICROSTRAINING

At two nonintegrated papermills, full-scale coagulation/microstraining facilities are used for treating rag pulp and fine paper effluents (35,36). Coagulant usage includes the addition of 1 mg/l of polymer plus the addition of alum or caustic for pH adjustment. Typically, suspended solids and BOD_5 reductions to 10 mg/l and 50 mg/l, respectively, are achieved. When properly operating, treatment approaching that achievable through the application of biological treatment has been obtained. It has been observed that upsets caused by such practices as paper machine washup with high alkaline cleaners affect the effectiveness of the technology.

ELECTROCHEMICAL TREATMENT

Electrochemical treatment technology involves the application of an electrical current to the effluent to convert chloride to chlorate, hypochlorite, and chlorine. The chlorine and hypochlorite can oxidize organic compounds and be reduced again to chloride ions. The process then repeats in a catalytic fashion. The oxidation of organic compounds reduces the BOD_5 and color. A significant advantage of the process is that no sludge is produced.

It has been found that an 80% reduction of color in wholemill bleached kraft effluent and a 90% reduction of color in caustic extract can be achieved through electrochemical treatment (37). Similar results have been achieved when using a lead dioxide or a graphite anode.

Another variation to this process involves the use of hydrogen gas bubbles generated in the process to float solids and separate scum. An electrochmeical unit with graphite anodes and stainless steel cathodes can coagulation in kraft white water (38). Release of hydrogen bubbles in the process cause solids removal by flotation, with total suspended solids being reduced to 2 to 4 mg/l.

Another study found significant color and TOC reductions in bleachery wastes by application of electrolytic cells using an aluminum anode (39). Color removals from chlorination and caustic extraction effluents were 92% and 99%, respectively, while TOC removals were 69% and 89%, respectively. Specific concentrations, however, were not reported.

ION FLOTATION

This process involves the addition of a surfactant ion of opposite charge to the ion to be removed. The combining of these ions results in a precipitate, the colligend. The colligend is removed by passage of air bubbles through the waste and collection of the resulting floating solids.

Many of the chromophoric (color producing) organics in pulp, paper, and paperbord mill wastewaters are negatively charged, making this process suitable for the removal of color. A variety of commerical grade cationic surfactants were tested and Aliquat 221 was found to be very effective (40). The process removed over 95% of the color from bleached kraft effluents.

AIR/CATALYTIC/CHEMICAL OXIDATION

Complete oxidation of organics found in pulp, paper, and paperboard mill wastewaters to carbon dioxide and water is a significant potential advantage of oxidation processes. Partial oxidation coupled with biological treatment may have economic and/or technical advantages over biological treatment alone.

Past studies of oxidative processes dealt principally with COD and TOC as a measure of performance. A thorough compilation of related studies found that most were performed with wastewater other than those resulting from the production of pulp, paper, and paperboard. Some tentative conclusions, though, may still be drawn (1).

- Complete oxidation with air can occur under extreme temperature and pressure, high intensity irradiation, with air at ambient conditions in the presence of excessive amounts of strong oxidants (O_3, H_2O_2 or ClO_2), or with air or oxygen in the presence of catalysts such as certain metal oxides.

- Major BOD_5 reductions can only be achieved under conditions similar to those required for nearly complete oxidation.

STEAM STRIPPING

Steam stripping involves the removal of volatiles from concentrated streams. Steam stripping at a kraft mill is capable of removing 60% to 85% of the BOD_5 from condensate streams. The ability of the process to remove specific pollutants (including toxic and nonconventional pollutants) depends on the relative boiling points of the pollutants with respect to that of water (i.e., the pollutants must be volatile). Resin acids have boiling points in the range of 250°C and, thus, are not readily stripped through application of this process.

Steam stripping was evaluated for its ability to detoxify condensates from sulfite waste liquor evaporators (41). This stream accounted for 10% of the whole mill effluent toxicity and 28% of the total BOD_5 load. Toxicity in the condensate stream was attributed to acetic acid, furfural, eugenol, juvabione, and abietic acid. The application of steam stripping had no observable effect on the toxicity of the stream, although the total organic content was reduced.

Steam stripping of kraft mill digester and evaporator condensates was employed on a mill scale for control of total reduced sulfur (TRS) compounds (42). This process removed 97% of the TRS compounds.

ULTRAFILTRATION

Wastewater treatment by ultrafiltration involves removal of macromolecules from wastewater by means of membranes of specified molecular size. Wastewater is forced through the membranes under pressure. The size of the molecules to be removed dictates the permeability (size opening) of the ultrafiltration membrane.

Two types of ultrafiltration were used for nonconventional pollutant removal from two bleached kraft caustic extraction effluents (4). Substantial removals of epoxystearic acid, dichlorostearic acid, trichloroguaiacol, and tetrachloroguaiacol were obtained in each case. Chlorinated resin acids were effectively removed by one system but not the other.

The first system employed only one spiral wound membrane, with a surface area of 3.7 m^2. Filtration of suspended solids larger than 10 micrometers was accomplished prior to ultrafiltration. The system was operated at 28.4 liters per minute and a pH of 11 to 11.5. The system achieved 50% to 80% reduction of chlorinated phenolics but only 0% to 15% removal of chlorinated resin acids. The lower percent removals of chlorinated resin acids reflect a low intial concentration of these pollutants in the waste.

The second system treated an effluent volume of 12.5 liters per minute using a tubular cellulose acetate membrane with a surface area of 1.1 m^2. The system operated at a pH of 9.5 to 10.5 and inlet and outlet pressures of 15.0 ATM and 5.8 ATM, respectively. Filtration of all particles larger than 10 micrometers was accomplished prior to ultrafiltration. This system removed approximately 80% to 85% of all chlorinated resin acids, chlorinated phenolics, and other acids.

Removal of color, lignosulfonate, COD, and solids from sulfite liquor was examined after the application of ultrafiltration. Removals on the order of 30% to 50% were observed for color, lignosulfonate, COD, and TSS.

REVERSE OSMOSIS/FREEZE CONCENTRATION

Reverse osmosis employs pressure to force a solvent through the membrane against the natural osmotic force. This is the same type of process as ultrafiltration except that the membranes used for reverse osmosis reject lower molecular weight solutes. This means that lower flux rates occur; there is also a need for a higher operating pressure difference across the membrane than those necessary for ultrafiltration.

Reverse osmosis is employed at a NSSC mill where 270 kkg/day of corrugating medium are produced. The system allows operation of a closed white water system. The system achieved BOD_5 reductions of approximately 90% and removes essentially all resin and fatty acids (4). The 320 liter per minutes reverse osmosis unit employs 288 modules, each with 1.55 m^2 of area provided by 18 cellulose acetate tubes. The system operates at 41 ATM and 38°C. White water feed has been found to contain 300 mg/l TSS and 40,000 to 60,000 mg/l total dissolved solids, with initial resin and fatty acid levels of: abietic, 1.5 mg/l; dehydroabietic, 2.62 mg/l; isopimaric, 2.75 mg/l; pimaric, 0.82 mg/l; oleic, 4.86 mg/l; linoleic 7.23 mg/l; and linolenic, 0.27 mg/l. The maximum removal capacity is not known since final concentrations are below detection limits (4).

Reverse osmosis can be followed by freeze concentration whereby the effluent is frozen to remove pollutants selectively. Freeze concentration takes advantage of the fact that when most aqueous solutions freeze, the ice crystal is almost 100% water. This process was evaluated on three bleachery effluents (43). Reverse osmosis along resulted in a concentrate stream of roughly 10% of the volume of the raw feed. Freeze concentration reduced the concentrate stream volume by a factor of 5 while essentially all the impurities were retained in the concentrate. Thus, the two processes employed in tandem resulted in a concentrate stream consisting of roughly 2% of the original feed volume that contained essentially all of the dissolved solids. It was reported that the purified effluent was of sufficient quality that it could be returned to the process for reuse.

AMINE TREATMENT

This treatment is based on the ability of high molecular weight amines to form organophilic precipitates. These precipitates are separated and redissolved in a small amount of strong alkaline solution (white water). By so doing, the amine is regenerated for use, with no sludge produced.

A study was conducted to determine the optimum process conditions for employing high molecular weight amines for color, BOD_5 and COD reductons in bleached kraft mill effluents (44). Final effluent concentrations for BOD_5, COD, and color were 80 to 350 mg/l, 390 to 760 mg/l, and 80 to 450 APHA units, respectively. Reported removals were 10% to 74%, 36% to 78%, and 94% to 98%, respectively, using Kemamine T-1902D in a solvent of Sotrol 170.

POLYMERIC RESIN TREATMENT

Polymeric resin wastewater treatment processes make use of adsorption and ion exchange mechanisms to remove pollutants from the wastewater. Resin columns are commonly employed; they are reactivated after completion of the treatment cycle by means of acid or alkaline solutions. It has been reported that weakly basic ion exchange resins, based on a phenol/formaldehyde matrix, are superior in treating pulp and paper bleach plant effluents (45). Prior to resin treatment, it is advantageous to screen and filter the waste streams and adjust the pH to 2 or 3.

In one resin adsorption system a full countercurrent wash is used. Effluent from the caustic first extraction stage is reused on the chlorination stage washer after color removal through resin adsorption (46).

Pollutants may be removed from the resin by elution with caustic or oxidized white liquor. The eluate at 10% concentration is mixed with the weak black liquor to be evaporated and burned in the recovery boiler. The resin is reactivated with the chlorination effluent. The chlorination stage effluent reactivates the resin and is simultaneously decolorized. The total mill BOD_5 load is reduced by 30% and the color load by 90% (46).

Another resin adsorption process involves the use of Amberlite XAD-8 resin to decolorize bleaching effluent after filtration (1). The resin can be reactivated without the generation of waste sludge. This reactivation may be accomplished by using mill white liquor. The adsorption capacity of Amberlite XAD-2 resin was compared to Filtrasorb 300 activated carbon. The resin was more effective in removing most aromatic compounds, phthalate esters, and pesticides; carbon was more effective at removing alkenes. Neither adsorbant was effective in removing acidic compounds. The tests involved use of laboratory solutions of 100 organic compounds at an initial concentration of 100 μg/l.

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APPENDIX D

OSHA REGULATIONS GOVERNING PULP, PAPER AND PAPERBOARD MILLS
(29 CFR 1910.261)

Subpart R—Special Industries

§ 1910.261 Pulp, paper, and paperboard mills.

(a) *General requirements*—(1) *Application.* This section applies to establishments where pulp, paper, and paperboard are manufactured and converted. This section does not apply to logging and the transportation of logs to pulp, paper, and paperboard mills.

(2) *Standards incorporated by reference.* Standards covering issues of occupational safety and health which have general application without regard to any specific industry are incorporated by reference in paragraphs (b) through (m) of this section and in subparagraphs (3) and (4) of this paragraph and made applicable under this section. Such standards shall be construed according to the rules set forth in § 1910.5.

(3) *General incorporation of standards.* Establishments subject to this section shall comply with the following standards of the American National Standards Institute:

(i) Practice for Industrial Lighting, A11.1—1965 (R-1970).

(ii) Safety Requirements for Floor and Wall Openings, Railings, and Toe Boards, A12.1—1967.

(iii) Scheme for the Identification of Piping Systems, A13.1—1956.

(iv) Safety Code for Portable Wood Ladders, A14.1—1968.

(v) Safety Code for Portable Metal Ladders A14.2—1956.

(vi) Safety Code for Fixed Ladders, A14.3—1956.

(vii) Safety Code for Elevators, Dumbwaiters, and Moving Walks, A17.1—1965, including Supplements A17.1a—1967, A17.1b—1968, A17.1c—1969, and A17.1d—1970.

(viii) Practice for the Inspection of Elevators (Inspector's Manual), A17.2—1960, including Suppelements A17.2a—1965 and A17.2b—1967.

(ix) Safety Code for Mechanical Power-Transmission Apparatus, B15.1—1953 (Reaffirmed 1958).

(x) Safety Code for Conveyors, Cableways, and Related Equipment, B20.1—1957.

(xi) Safety Code for Cranes, Derricks, and Hoists, B30.2—1943 (Reaffirmed 1952 and partially revised by B30.2.0—1967 and B30.5—1968).

(xii) Overhead and Gantry Cranes, B30.2.0—1967 (Partial Revision of B30.2—1943).

(xiii) Crawler, Locomotive, and Truck Cranes, B30.5—1968 (Partial Revision of B30.2—1943).

(xiv) Power Piping, B31.1.0—1967 and addenda B31.10a—1969. Fuel Gas Piping, B31.2—1968.

(xv) Safety Code for Powered Industrial Trucks, B56.1—1969.

(xvi) Identification of Gas-Mask Canisters, K13.1—1967.

(xvii) Safety Code for Woodworking Machinery, O1.1—1954 (Reaffirmed 1961).

(xviii) Requirements for Sanitation in Places of Employment, Z4.1—1968.

(xix) Safety Code for Ventilation and Operation of Open-Surface Tanks, Z9.1—1951.

(xx) Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2—1960.

(xxi) Prevention of Sulfur Fires and Explosions, Z12.12—1968.

(xxii) Method of Measurement of Real-Ear Attenuation of Ear Protectors at Threshold, Z24.22—1957.

(xxiii) Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying, Z33.1—1961.

(xxiv) Specifications for Accident Prevention Signs, Z35.1—1968.

(xxv) Practice for Occupational and Educational Eye and Face Protection, Z87.1—1968 (Partial Revision of Z2.1—1959).

(xxvi) Practices for Respiratory Protection, Z88.2—1969.

(xxvii) Safety Requirements for Industrial Head Protection, Z89.1—1969.

(4) *Other standards.* The following standards shall be considered standards under this section:

(i) ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels, including addenda 1969.

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(ii) Building Exits Code for Life Safety from Fire, NFPA 101—1970.

(iii) Safety in the Handling and Use of Explosives, IME Pamphlet No. 17, July 1960, Institute of Makers of Explosives.

(b) *Safe practices*—(1) *Guards.* All driving mechanisms, power-transmission apparatus, and prime movers shall be constructed, guarded, and used in conformity with American National Standard B15.1—1953 (Reaffirmed 1958).

(2) *Personal protective clothing and equipment.* Foot protection, shinguards, hard hats, noise attenuation devices, or other personal protective clothing and equipment shall be worn when the extent of the hazard is such as to warrant their use. Such equipment shall be worn whenever specifically required by other paragraphs of this section. All equipment shall be maintained in accordance with applicable American National Standards. Respirators, goggles, and protective masks, rubber gloves, rubber boots, and other such equipment shall be cleaned and disinfected before being used by another employee. Eye, head, respiratory, and ear protection, where specified, shall conform to American National Standards Z24.22—1957, Z87.1—1968, Z88.2—1969, and Z89.1—1969.

(3) *Floors and platforms.* Floors, platforms, and work surfaces shall be maintained in accordance with American National Standard A12.1—1967.

(4) *Lockouts.* Devices such as padlocks shall be provided for locking out the source of power at the main disconnect switch. Before any maintenance, inspection, cleaning, adjusting, or servicing of equipment (electrical, mechanical, or other) that requires entrance into or close contact with the machinery or equipment, the main power disconnect switch or valve, or both, controlling its source of power or flow of material, shall be locked out or blocked off with padlock, blank flange, or similar device.

(5) *Vessel entering.* Lifelines and safety harness shall be worn by anyone entering closed vessels, tanks, chip bins, and similar equipment, and a person shall be stationed outside in a position to handle the line and to summon assistance in case of emergency. The air in the vessels shall be tested for oxygen deficiency and the presence of both toxic and explosive gases and vapors, before entry into closed vessels, tanks, etc., is permitted. Self-contained air- or oxygen-supply masks shall be readily available in case of emergency. Work shall not be done on equipment under conditions where an injury would result if a valve were unexpectedly opened or closed unless the valve has been locked in a safe position.

(6) *Industrial power trucks.* All industrial power truck operations shall conform to American National Standard B56.1—1969. All forklift trucks shall be provided with overhead guards. All guards shall be designed in compliance with American National Standard B56.1—1969. Design requirements shall provide protection for the liquid petroleum tank.

(7) *Emergency lighting.* Emergency lighting shall be provided wherever it is necessary for employees to remain at their machines or stations to shut down equipment in case of power failure. Emergency lighting shall be provided at stairways and passageways or aisleways used by employees for emergency exit in case of power failure. Emergency lighting shall be provided in all plant first aid and medical facilities.

(c) *Handling and storage of pulpwood and pulp chips*—(1) *Handling pulpwood with forklift trucks.* Where large forklift trucks, or lift trucks with clam-jaws, are used in the yard, the operator's enclosed cab shall be provided with an escape hatch, whenever the hydraulic arm blocks escape through the side doors.

(2) *Handling pulpwood with cranes or stackers.* (i) Where locomotive cranes are used for loading or unloading pulpwood, the pulpwood shall be piled so as to allow a clearance of not less than 24 inches between the pile and the end of the cab of any locomotive crane in use, when the cab is turned in any working position.

(ii) The minimum distance of the pulpwood pile from the centerline of a standard-gage track shall be maintained at not less than 8½ feet.

(iii) Logs shall be piled in an orderly and stable manner, with no projection into walkways or roadways.

(iv) Railroad cars shall not be spotted on tracks adjacent to the locomotive cranes unless a 24-inch clearance is maintained, as required in paragraph (c)(2)(i) of this section.

(v) The handling and storage of other materials shall conform to paragraphs (c)(2) (i) and (ii) of this section with respect to clearance.

(vi) Equipment and practices shall conform to American National Standards B30.2—1943 (reaffirmed 1952) and B30.2.0—1967.

(vii) Personal protective equipment for such uses as foot, head, and eye protection shall be required for workers on a job basis.

(viii) No person shall be permitted to walk beneath a suspended load, bucket, or hook.

(3) *Handling pulpwood from ships.* (i) Ladders and gangplanks with railings to boat docks shall meet the requirements of American National Standards A12.1—1967, A14.1—1968, A14.2—1956, and A14.3—1956, and shall be securely fastened in place.

(ii) The hatch tender shall be required to signal the hoisting engineer to move the load only after the men working in the hold are in the clear.

(iii) The air in the ship's hold, tanks, or closed vessels shall be tested for oxygen deficiency and for both toxic and explosive gases and vapors.

(4) *Handling pulpwood from flatcars and all other railway cars.* (i) Railroad flatcars for the conveyance of pulpwood loaded parallel to the length of the car shall be equipped with safety-stake pockets.

(ii) Where pulpwood is loaded crosswise on a flatcar sufficient stakes of sizes not smaller than 4 by 4 inches shall be used to prevent the load from shifting.

(iii) When it is necessary to cut stakes, those on the unloading side should be partially cut through first, and then the binder wires cut on the opposite side. Wire cutters equipped with long extension handles shall be used. No person shall be permitted along the dumping side of the car after the stakes have been cut.

(iv) When steel straps without stakes are used, the steel straps shall be cut from a safe area to prevent employees from being struck by the falling logs.

(v) Flatcars and all other cars shall be chocked during unloading. Where equipment is not provided with hand brakes, rail clamping chocks shall be used.

(vi) A derail shall be used to prevent movement of other rail equipment into cars where persons are working.

(5) *Handling pulpwood from trucks.* (i) Cutting of stakes and binder wires shall be done in accordance with paragraph (c)4(iii) of this section.

(ii) Where binder chain and steel stakes are used, the binder chains shall be released and the stakes tripped from the opposite side of the load spillage.

(iii) Where binder chains and crane slings are used, the crane slings shall be attached and taut before the binder chains are released. The hooker shall see that the helper is clear before signaling for the movement of the load.

(6) *Handling pulp chips from railway cars.* (i) All cars shall be securely fastened in place and all employees in the clear before dumping is started.

(ii) Personal protective equipment for such uses as foot, head, and eye protection shall be provided, and employees shall wear the equipment when working in the woodyard. Ear protection shall be provided when the noise level may be harmful.

(7) *Handling pulp chips from trucks and trailers.* (i) All trucks and trailers shall be securely fastened in place and all employees in the clear before dumping is started.

(ii) Personal protective equipment shall be in accordance with paragraph (c)(6)(ii) of this section.

(8) *Cranes.* (i) Crane boom and load capacities as specified by the manufacturer shall be posted in the cab of the crane in accordance with American National Standards B30.2—1943 (reaffirmed 1968) and B30.2.0—1967.

(ii) A safety device such as a heavy chain or cable at least equal in strength to the lifting cables shall be fastened to the boom and to the frame of the boom crane (if it is other than locomotive) at the base. Alternatively, a telescoping safety device shall be fas-

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tened to the boom and to the cab frame, so as to prevent the boom from snapping back over the cab in the event of lifting cable breakage.

(iii) A crane shall not be operated where any part thereof may come within 10 feet of overhead powerlines (or other overhead obstructions) unless the powerlines have been deenergized. The boom shall be painted bright yellow from and including the head sheave to a point 6 feet down the boom towards the cab.

(iv) Standard signals for the operation of cranes shall be established for all movements of the crane, in accordance with American National Standards B30.2—1943 (reaffirmed 1968) and B30.2.0—1967.

(v) Only one member of the crew shall be authorized to give signals to the crane operator.

(vi) All cranes shall be equipped with a suitable warning device such as a horn or whistle.

(vii) A sheave guard shall be provided beneath the head sheave of the boom.

(9) *Traffic warning signs or signals.* (i) A flagman shall direct the movement of cranes or locomotives being moved across railroad tracks or roads, and at any points where the vision of the operator is restricted. The flagman must always remain in sight of the operator when the crane or locomotive is in motion. The blue flag policy shall be used to mark stationary cars day and night. This policy shall include marking the track in advance of the spotted cars (flag for daytime, light for darkness).

(ii) After cars are spotted for loading or unloading, warning flags or signs shall be placed in the center of the track at least 50 feet away from the cars and a derail set to protect workmen in the car.

(10) *Illumination.* Artificial illumination shall be provided when loading or unloading is performed after dark, in accordance with American National Standard A11.1—1965 (R—1970).

(11) *Bridge or dock plates.* The construction and use of bridge or dock plates shall conform to requirements of American National Standard B56.1—1969.

(12) *Barking devices.* When barking drums are employed in the yard, the requirements of paragraph (e)(12) of this section shall apply.

(13) *Hand tools.* Handles of wood hooks shall be locked to the shank to prevent them from rotating.

(14) *Removal of pulpwood.* (i) The ends of a woodpile shall be properly sloped and cross-tiered into the pile. Upright poles shall not be used at the ends of woodpiles. To knock down wood from the woodpile, mechanical equipment shall be used to permit employees to keep in the clear of loosened wood.

(ii) If dynamite is used to loosen the pile, only authorized personnel shall be permitted to handle and discharge the explosive. An electric detonator is preferable for firing; if a fuse is used, it shall be an approved safety fuse with a burning rate of not less than 120 seconds per yard and a minimum length of 3 feet, in accordance with Safety in the Handling and Use of Explosives, IME Pamphlet No. 17, July 1960.

(15) *Belt conveyors.* (i) The sides of the conveyor shall be constructed so that the wood will not fall off.

(ii) Where conveyors cross passageways or roadways, a horizontal platform shall be provided under the conveyor extending out from the sides of the conveyor a distance equal to 1½ times the length of the wood handled. The platform shall extend the width of the road plus 2 feet on each side and shall be kept free of wood and rubbish. The edges of the platform shall be provided with toeboards or other protection to prevent wood from falling, in accordance with American National Standard A12.1—1967.

(iii) All conveyors for pulpwood shall have the inrunning nips between chain and sprockets guarded; also, turning drums shall be guarded.

(iv) Every belt conveyor shall have an emergency stop cable extending the length of the conveyor so that it may be stopped from any location along the line, or conveniently located stop buttons within 10 feet of each work station, in accordance with American National Standard B20.1—1957.

(16) *Signs.* Where conveyors cross walkways or roadways in the yards,

signs reading "Danger—Overhead Conveyor" or an equivalent warning shall be erected, in accordance with American National Standard Z35.1—1968.

(d) *Handling and storage of raw materials other than pulpwood or pulp chips*—(1) *Personal protective equipment.* (i) Whenever possible, all dust, fumes, and gases incident to handling materials shall be controlled at the source, in accordance with American National Standard Z9.2—1960. Where control at the source is not possible, respirators with goggles or protective masks shall be provided, and employees shall wear them when handling alum, clay, soda ash, lime, bleach powder, sulfur, chlorine, and similar materials, and when opening rag bales.

(ii) When handling liquid acid or alkali, workmen shall be provided with approved eye and face protection and protective clothing, in accordance with American National Standard Z87.1—1968.

(2) *Clearance.* (i) When materials are being piled inside a building and upon platforms, an aisle clearance at least 3 feet greater than the widest truck in use shall be provided.

(ii) Baled paper and rags stored inside a building shall not be piled closer than 18 inches to walls, partitions, or sprinkler heads.

(3) *Piling and unpiling pulp.* (i) Piles of wet lap pulp (unless palletized) shall be stepped back one-half the width of the sheet for each 8 feet of pile height. Sheets of pulp shall be interlapped to make the pile secure. Pulp shall not be piled over pipelines to jeopardize pipes, or so as to cause overloading of floors, or to within 18 inches below sprinkler heads.

(ii) Piles of pulp shall not be undermined when being unpiled.

(iii) Floor capacities shall be clearly marked on all floors.

(4) *Chocking rolls.* (i) Where pulp or paper rolls are of uniform size, cribbing should be constructed to keep rolls from moving.

(ii) Where rolls are pyramided two or more high, chocks shall be installed between each roll on the floor and at every row. The face of each chock should be formed on a radius to conform to the average roll size in use. Where pulp and paper rolls are stored on smooth floors in processing areas, rubber chocks with wooden core shall be used.

(iii) When rolls are decked two or more high, the bottom rolls shall be chocked on each side to prevent shifting in either direction.

(iv) A supply of portable roll chocks should be available to be used where there are gaps in the bottom row of rolls.

(e) *Preparing pulpwood*—(1) *Gang and slasher saws.* A guard shall be provided in front of all gang and slasher saws to protect workers from wood thrown by saws. A guard shall be placed over tail sprockets.

(2) *Slasher tables.* Saws shall be stopped and power switches shall be locked out and tagged whenever it is necessary for any person to be on the slasher table.

(3) *Slasher drive belts, pulleys, and shafts.* All belts, pulleys, and shafts shall be guarded in accordance with American National Standard B15.1—1955 (reaffirmed 1958).

(4) *Runway to the jack ladder.* The runway from the pond or unloading dock to the table shall be protected with standard handrails and toeboards. Inclined portions shall have cleats or equivalent nonslip surfacing, in accordance with American National Standard A12.1—1967. Protective equipment shall be provided for persons working over water.

(5) *Guards below table.* Where not protected by the frame of the machine, the underside of the slasher saws shall be enclosed with guards.

(6) *Conveyors.* The requirements of paragraph (c)(15)(iv) of this section shall apply.

(7) *Circular saws (not slasher saws).* Saws shall be provided with standard guards, in accordance with American National Standard 01.1—1954 (reaffirmed 1961).

(8) *Barker feed.* Each barker shall be equipped with a feed and turnover device which will make it unnecessary for the operator to hold a bolt or log by hand during the barking operation. Eye, ear, and head protection shall be provided for the operator, in accordance with paragraph (b)(2) of this section.

(9) *Guards.* A guard shall be installed around barkers to confine flying particles, in accordance with American National Standard B15.1—1953 (Reaffirmed 1958).

(10) *Stops.* All control devices shall be locked out and tagged when knives are being changed.

(11) *Speed governor.* Water wheels, when directly connected to barker disks or grinders, shall be provided with speed governors, if operated with gate wide open.

(12) *Continuous barking drums.* (i) When platforms or floors allow access to the sides of the drums, a standard railing shall be constructed around the drums. When two or more drums are arranged side by side, proper walkways with standard handrails shall be provided between each set, in accordance with paragraph (b)(3) of this section.

(ii) Sprockets and chains, gears, and trunnions shall have standard guards, in accordance with paragraph (b)(1) of this section.

(iii) Whenever it becomes necessary for a workman to go within a drum, the driving mechanism shall be locked and tagged, at the main disconnect switch, in accordance with paragraph (b)(4) of this section.

(13) *Intermittent barking drums.* In addition to motor switch, clutch, belt shifter, or other power disconnecting device, intermittent barking drums shall be equipped with a device which may be locked to prevent the drum from moving while it is being emptied or filled.

(14) *Hydraulic barkers.* Hydraulic barkers shall be enclosed with strong baffles at the inlet and the outlet. The operator shall be protected by at least five-ply laminated glass.

(15) *Splitter block.* The block upon or against which the wood is rested shall have a corrugated surface or other means provided that the wood will not slip. Wood to be split, and also the splitting block, shall be free of ice, snow, or chips. The operator shall be provided with eye and foot protection. A clear and unobstructed view shall be maintained between equipment and workers around the block and the workers' help area.

(16) *Power control.* Power for the operation of the splitter shall be controlled by a clutch or equivalent device.

(17) *Knot cleaners.* The operators of knot cleaners of the woodpecker type shall wear eye protection equipment. Knot cleaners of the woodpecker type should be enclosed to protect passersby from flying chips.

(18) *Chipper spout.* The feed system to the chipper spout shall be arranged in such a way that the operator does not stand in a direct line with the chipper spout. All chipper spouts shall be enclosed to a height of at least 42 inches from the floor or operator's platform. If practical, a mirror should be installed to enable the chipper feeder to see the chute. When other protection is not sufficient, the operator shall wear a safety belt line. The safety belt line shall be fastened in such a manner as to make it impossible for the operator to fall into the throat of the chipper. Ear protection equipment shall be worn by the operator and others in the immediate area if there is any possibility that the noise level may be harmful (see § 1910.95).

(19) *Carriers for knives.* Carriers shall be provided and used for transportation of knives.

(f) *Rag and old paper preparation*—(1) *Ripping and trimming tools.* (i) Hand knives and scissors shall have blunt points, shall be fastened to the table with chain or thong, and shall not be carried on the person but placed safely in racks or sheaths when not in use.

(ii) Hand knives and sharpening steels shall be provided with guards at the junction of the handle and the blade.

(2) *Shredders, cutters, and dusters.* (i) Rotating heads or cylinders shall be completely enclosed except for an opening at the feed side sufficient to permit only the entry of stock. The enclosure shall extend over the top of the feed rolls. It shall be constructed either of solid material or with mesh or openings not exceeding one-half inch and substantial enough to contain flying particles and prevent accidental contact with moving parts. The enclosure shall be bolted or locked into place.

(ii) A smooth-pivoted idler roll resting on the stock or feed table shall be provided in front of feed rolls except when arrangements prevent the operator from standing closer than 36 inches to any part of the feed rolls.

(iii) Any manually fed cutter, shredder, or duster shall be provided with an idler roll as per subdivision (ii) of this subparagraph or the operator shall use special hand-feeding tools.

(iv) Hoods of cutters, shredders, and dusters shall have exhaust ventilation, in accordance with American National Standard Z9.2—1960.

(3) *Blowers.* (i) Blowers used for transporting rags shall be provided with feed hoppers having outer edges located not less than 48 inches from the fan.

(ii) The arrangement of the blower discharge outlets and work areas shall be such as to prevent material from falling on workers.

(4) *Conveyors.* Conveyors and conveyor drive belts and pulleys shall be fully enclosed or, if open and within 7 feet of the floor, shall be constructed and guarded in accordance with paragraph (c)(15) of this section and American National Standards B15.1—1953 (Reaffirmed 1958) and B20.1—1957.

(5) *Dust.* Measures for the control of dust shall be provided, in accordance with American National Standards Z33.1—1961, Z87.1—1968, and Z88.2—1969.

(6) *Rag cookers.* (i) When cleaning, inspection, or other work requires that persons enter rag cookers, all steam and water valves, or other control devices, shall be locked and tagged in the closed or "off" position. Blank flanging of pipelines is acceptable in place of closed and locked valves.

(ii) When cleaning, inspection, or other work requires that persons must enter the cooker, one person shall be stationed outside in a position to observe and assist in case of emergency, in accordance with paragraph (b)(5) of this section.

(iii) Supplied air respirators should be worn by persons when spreading material inside cookers.

(iv) Rag cookers shall be provided with safety valves in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels—1968, with Addenda.

(g) *Chemical processes of making pulp*—(1) *Sulfur burners.* (i) Sulfur-burner houses shall be safely and adequately ventilated, and every precaution shall be taken to guard against dust explosion hazards and fires, in accordance with American National Standards Z9.2—1960 and Z12.12—1968.

(ii) Nonsparking tools and equipment shall be used in handling dry sulfur.

(iii) Sulfur storage bins shall be kept free of sulfur dust accumulation, and buildings should be designed with explosion relief, in accordance with American National Standard Z9.2—1960.

(iv) Electrical equipment shall be of the explosion-proof type, in accordance with the requirements of §§ 1910.322 through 1910.328.

(v) Sulfur-melting equipment shall not be located in the burner room.

(2) *Protection for employees (acid plants).* (i) Gas masks, fitted with canisters containing absorbents for the particular acids, gases, or mists involved, shall be provided for employees of the acid department.

(ii) Supplied air respirators shall be strategically located for emergency and rescue use.

(iii) During inspection, repairs, or maintenance of acid towers, the workman shall be provided with eye protection, a supplied air respirator, a safety belt, and an attached lifeline. The line shall be extended to an attendant stationed outside the tower opening.

(3) *Acid tower structure.* Outside elevators shall be inspected daily during winter months when ice materially affects safety. Elevators, runways, stairs, etc., for the acid tower shall be inspected monthly for defects that may occur because of exposure to acid or corrosive gases.

(4) *Tanks (acid).* (i) Tanks shall be free of acid and shall be washed out with water, and fresh air shall be blown into them before allowing men to enter. Men entering the tanks shall be provided with supplied air respirators, lifebelts, and attached lifelines.

(ii) A man shall be stationed outside to summon assistance if necessary. All intake valves to a tank shall be blanked off or disconnected.

(5) *Clothing.* Where lime slaking takes place, employees shall be provided with rubber boots, rubber gloves, protective aprons, and eye protection. A deluge shower and eye fountain shall be provided to flush the skin and eyes to counteract lime or acid burns.

(6) *Lead burning.* When lead burning is being done within tanks, fresh air shall be forced into the tanks so that fresh air will reach the face of the worker first and the direction of the current will never be from the source of the fumes toward the face of the workers. Supplied air respirators (constant-flow type) shall be provided.

(7) *Hoops for acid storage tanks.* Hoops of tanks shall be made of rods rather than flat strips and shall be safely maintained by scheduled inspections.

(8) *Chip and sawdust bins.* Steam or compressed-air lances, or other facilities, shall be used for breaking down the arches caused by jamming in chip lofts. No worker shall be permitted to enter a bin unless provided with a safety belt, with line attached, and an attendant stationed at the bin to summon assistance.

(9) *Exits (digester building).* At least one unobstructed exit at each end of the room shall be provided on each floor of a digester building.

(10) *Gas masks (digester building).* Gas masks shall be available. These masks shall furnish adequate protection against sulfurous acid and chlorine gases, and shall be inspected and tested at frequent intervals, not to exceed 1 month, in accordance with American National Standards Z87.1—1968, and Z88.2—1969.

(11) *Elevators.* (i) Elevators shall be constructed in accordance with American National Standard A17.1—1965.

(ii) Elevators shall be equipped with gas masks for the maximum number of passengers.

(iii) Elevators shall be equipped with an alarm system to advise of failure.

(12) *Blowoff valves and piping.* (i) The blowoff valve of a digester shall be arranged so as to be operated from another room, remote from safety valves.

(ii) Through bolts instead of cap bolts shall be used on all digester pipings.

(iii) Heavy duty pipe, valves, and fittings shall be used between the digester and blow pit. These valves, fittings, and pipes shall be inspected at least semiannually to determine the degree of deterioration and should be replaced when necessary.

(iv) Digester blow valves shall be pinned or locked in closed position throughout the entire cooking period.

(13) *Blow pits and blow tanks.* (i) Blow-pit openings shall be preferably on the side of the pit instead of on top. When located on top, openings shall be as small as possible and shall be provided with railings, in accordance with American National Standard A12.1—1967.

(ii) A specially constructed ladder shall be used for access to blow pits, to be constructed so that the door of the blow pit cannot be closed when the ladder is in place; other means shall be provided to prevent the closing of the pit door when anyone is in the pit.

(iii) A signaling device shall be installed in the digester and blow-pit rooms and chip bins to be operated as a warning before and while digesters are being blown.

(iv) Blow-pit hoops shall be maintained in a safe condition.

(14) *Blowing digester.* (i) Blowoff valves shall be opened slowly.

(ii) After the digester has started to be blown, the blowoff valve shall be left open, and the hand plate shall not be removed until the digester cook signals the blow-pit man that the blow is completed. Whenever it becomes necessary to remove the hand plate to clear stock, operators shall wear eye protection equipment and protective clothing to guard against burns from hot stock.

(iii) Means shall be provided whereby the digester cook shall signal the man in the chip bin before starting to load the digester.

(iv) When a digester is to be blown, or is blowing, red warning lights should be lighted, and these warning lights should be located in such a manner as to alert all personnel to leave whose duties do not require them to be in the vicinity of the digester during this operation.

(15) *Inspecting and repairing digester.* (i) Valves controlling lines leading into a digester shall be locked out and tagged. The keys to the locks shall be in the possession of a person or persons doing the inspecting or making repairs.

(ii) Fresh air shall be blown into the digester constantly while workmen are inside. Supplied air respirators shall be available in the event the fresh air supply fails or is inadequate.

(iii) No inspector shall enter a digester unless a lifeline is securely fastened to his body by means of a safety belt and at least one other experienced employee is stationed outside the digester to handle the line and to summon assistance. All ladders and lifelines shall be inspected before each use.

(iv) The concentration of lead dust in the air shall not exceed the limits specified in § 1910.1000.

(v) All employees entering digesters for inspection or repair work shall be provided with protective headgear. Eye protection and dust masks shall be provided to workmen while the old brick lining is being removed, in accordance with American National Standards, Z87.1—1968, Z88.2—1969, and Z99.1—1969.

(vi) Sanitary facilities shall be provided as specified in American National Standard Z4.1—1968.

(16) *Pressure tanks-accumulators (acid).* (i) Safety regulations governing inspection and repairing of pressure tanks-accumulators (acid) shall be the same as those specified in subparagraph (15) of this paragraph.

(ii) The pressure tanks-accumulators shall be inspected twice annually. (See the ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels—1968, with Addenda.)

(17) *Pressure vessels (safety devices).* (i) A safety valve shall be installed in a separate line from each pressure vessel; no hand valve shall be installed between this safety valve and the pressure vessel. Safety valves shall be checked between each cook to be sure they have not become plugged or corroded to the point of being inoperative. (See the ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels—1968, with Addenda.)

(ii) All safety devices shall conform to Paragraph U-2 in the ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels—1968, with Addenda.

(18) *Miscellaneous.* Insofar as the processes of the sulfate and soda operations are similar to those of the sulfite processes, the standard of paragraphs (g) (1) through (17) of this section shall apply.

(i) Quick operating showers, bubblers, etc., shall be available for emergency use in case of caustic soda burns.

(ii) Rotary tenders, smelter operators, and those cleaning smelt spouts shall be provided with eye protection equipment (fitted with lenses that filter out the harmful rays emanating from the light source) when actively engaged in their duties, in accordance with American National Standard Z87.1—1968.

(iii) Heavy-duty pipe, valves, and fittings shall be used between digester and blow pit. These shall be inspected at least semiannually to determine the degree of deterioration and repaired or replaced when necessary, in accordance with American National Standards B31.1—1955, B31.1a—1963, B31.1.0—1967, and B31.2—1968.

(iv) Smelt-dissolving tanks shall be covered and the cover kept closed, except when samples are being taken.

(v) Smelt tanks shall be provided with vent stacks and explosion doors, in accordance with American National Standard Z9.1—1951.

(19) *Blow lines.* (i) Each digester should have two independent "gas-off" lines and a reducing valve in the high-pressure steam line with a safety valve between the digester and the reducing valve. Two gas-off lines are recommended so that if one plugs with pulp, the other may be used, and the hazard of unplugging with the digester under pressure overcome. With the installation of a reducing valve and a safety valve, it is inprobable that pressure will exceed the maximum allowable working pressure of the digester.

(ii) Where the blow-off lines from several digesters lead into one pipe,

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the handles of all cocks should be set uniformly, or some equivalent arrangement should be provided so that a man can see at a glance whether all cocks are set right or not. If valves instead of cocks are provided, a type with a rising spindle should be used.

(iii) When blow lines from more than one digester lead into one pipe, the cock or valve of the blow line from the tank being inspected or repaired shall be locked or tagged out, or the line shall be disconnected and blocked off.

(20) *Furnace room.* Exhaust ventilation shall be provided where niter cake is fed into a rotary furnace and shall be so designed and maintained as to keep the concentration of hydrogen sulfide gas below the parts per million listed in § 1910.1000.

(21) *Inspection and repair of tanks.* All piping leading to tanks shall be blanked off or valved and locked or tagged. Any lines to sewers shall be blanked off to protect workers from air contaminants.

(22) *Welding.* Welding on blow tanks, accumulator tanks, or any other vessels where turpentine vapor or other combustible vapor could gather shall be done only after the vessel has been completely purged of fumes. Fresh air shall be supplied workers inside of vessels.

(23) *Turpentine systems and storage tanks.* Nonsparking tools and ground hose shall be used when pumping out the tank. The tank shall be surrounded by a berm or moat.

(h) *Bleaching*—(1) *Bleaching engines.* Bleaching engines, except the Bellmer type, shall be completely covered on the top, with the exception of one small opening large enough to allow filling but too small to admit a man. This opening should be covered by a door and guarded with standard guardrail and toeboards. Platforms leading from one engine to another shall have standard guardrails, in accordance with American National Standard A12.1—1967.

(2) *Bleach mixing rooms.* (i) The room in which the bleach powder is mixed shall be provided with adequate exhaust ventilation, located at the floor level, in accordance with American National Standard Z9.1—1951.

(ii) Chlorine gas shall be carried away from the work place and breathing area by an exhaust system. The gas shall be rendered neutral or harmless before being discharged into the atmosphere. The requirements of American National Standard Z9.2—1960 shall apply to this subdivision.

(iii) Gas masks shall be provided for emergency use, in accordance with American National Standards K13.1—1967 and Z88.2—1969.

(iv) For emergency and rescue work, independent self-contained oxygen masks or supplied air equipment shall be provided. (See American National Standards Z88.2—1969.)

(3) *Liquid chlorine.* (i) Tanks of liquid chlorine shall be stored in an adequately ventilated unoccupied room, where their possible leakage cannot affect workers.

(ii) Gas masks capable of absorbing chlorine shall be supplied, conveniently placed, and regularly inspected, and workers who may be exposed to chlorine gas shall be instructed in their use.

(iii) For emergency and rescue work, independent self-contained oxygen-type masks or supplied air equipment shall be provided.

(iv) At least two exits, remote from each other, shall be provided for all rooms in which chlorine is stored.

(v) Spur tracks upon which tank cars containing chlorine and caustic are spotted and connected to pipelines shall be protected by means of a derail in front of the cars. Blue flag policy should be invoked, in accordance with paragraph (c)(9) of this section.

(vi) All chlorine, caustic, and acid lines shall be marked for positive identification, in accordance with American National Standard A13.1—1967.

(4) *Bagged or drummed chemicals.* Bagged or drummed chemicals require efficient handling to prevent damage and spillage. Certain oxidizing chemicals used in bleaching pulp and also in some sanitizing work require added precautions for safety in storage and handling. In storage, these chemicals must be isolated from combustible materials and other chemicals with which they will react such as acids. They must also be kept dry, clean and uncontaminated.

(i) *Mechanical pulp process*—(1) *Pulp grinders.* (i) Water wheels directly connected to pulp grinders shall be provided with speed governors limiting the peripheral speed of the grinder to that recommended by the manufacturer.

(ii) Doors of pocket grinders shall be arranged so as to keep them from closing accidentally.

(2) *Butting saws.* Hood guards shall be provided on butting saws, in accordance with American National Standard O1.1—1954 (reaffirmed 1961).

(3) *Floors and platforms.* The requirements of paragraph (b)(3) of this section shall apply.

(4) *Personal protection.* Persons exposed to falling material shall wear eye, head, foot, and shin protection equipment, in accordance with American National Standards Z87.1—1968, Z88.2—1969, Z89.1—1969, and Z41.1—1967.

(j) *Stock preparation*—(1) *Pulp shredders.* (i) Cutting heads shall be completely enclosed except for an opening at the feed side sufficient to permit only entry of stock. The enclosure shall be bolted or locked in place. The enclosure shall be of solid material or with mesh or other openings not exceeding one-half inch.

(ii) Either a slanting feed table with its outer edge not less than 36 inches from the cutting head or an automatic feeding device shall be provided.

(iii) Repairs for cleaning of blockage shall be done only when the shredder is shutdown and control devices locked.

(iv) All power-driven mechanisms shall be guarded in accordance with paragraph (b)(1) of this section.

(2) *Pulp conveyors.* Pulp conveyors and conveyor drive belts and pulleys shall be fully enclosed, or if open and within 7 feet of the floor, shall be constructed and guarded in accordance with American National Standard B20.1—1957.

(3) *Floors, steps, and platforms.* The requirements of paragraph (b)(3) of this section shall apply.

(4) *Beaters.* (i) Beater rolls shall be provided with covers.

(ii) Guard rails 42 inches high shall be provided around beaters where tub tops are less than 42 inches from the floor, in accordance with paragraph (b)(3) of this section and American National Standard A12.1—1967.

(iii) When cleaning, inspecting, or other work requires that persons enter the beaters, all control devices shall be locked or tagged out, in accordance with paragraph (b)(4) of this section.

(iv) When beaters are fed from floor above, the chute opening, if less than 42 inches from the floor, shall be provided with a complete rail or other enclosure. Openings for manual feeding shall be sufficient only for entry of stock and shall be provided with at least two permanently secured crossrails, in accordance American National Standard A12.1—1967.

(v) When beaters are fed manually from the floor above, conveniently located emergency stop devices should be provided at the top level.

(vi) Floors around beaters shall be provided with sufficient drainage to remove wastes.

(5) *Pulpers.* (i) All pulpers having the top or any other opening of vessel less than 42 inches from the floor or work platform shall have such openings guarded by railed or other enclosures. For manual charging, openings shall be sufficient only to permit the entry of stock and shall be provided with at least two permanently secured crossrails, in accordance with American National Standard A12.1—1967.

(ii) When cleaning, inspecting, or other work requires that persons enter the pulpers, they shall be equipped with safety belt and lifeline, and one person shall be stationed outside at a position to observe and assist in case of emergency.

(iii) When cleaning, inspecting, or other work requires that persons enter pulpers, all steam, water, or other control devices shall be locked or tagged out. Blank flanging and tagging of pipe lines is acceptable in place of closed and locked or tagged valves. Blank flanging of steam and water lines shall be acceptable in place of valve locks.

(iv) All power mechanisms shall be guarded in accordance with American National Standard B15.1—1953 (reaffirmed 1958).

(6) *Stock chests.* (i) All control devices shall be locked or tagged out

when persons enter stock chests, in accordance with paragraph (b)(4) of this section.

(ii) All power mechanisms shall be guarded in accordance with paragraph (b)(1) of this section.

(iii) When cleaning, inspecting, or other work requires that persons enter stock chests, they shall be provided with a low-voltage extension light.

(k) *Machine room*—(1) *Emergency stops.* Paper machines shall be equipped with devices that will stop the machine quickly in an emergency. The devices shall consist of push buttons for electric motive power (or electrically operated engine stops), pull cords connected directly to the prime mover, control clutches, or other devices, interlocked with adequate braking action. The devices shall be tested periodically by making use of them when stopping the machine and shall be so located that any person working on the machine can quickly disconnect the machine from the source of power in case of emergency.

(2) *Drives.* (i) All drives, pulleys, couplings, and shafts on equipment requiring service while operating shall have standard guards in accordance with paragraph (b)(1) of this section.

(ii) All drives shall be provided with lockout devices at the power switch which interrupts the flow of current to the unit.

(iii) All ends of rotating shafts including dryer drum shafts shall be completely guarded.

(iv) All accessible disengaged doctor blades should be covered.

(v) All exposed shafts shall be guarded. Crossovers shall be provided.

(vi) Oil cups and grease fittings shall be placed in a safe area remote from nip and heat hazards.

(3) *Protective equipment.* Face shields, aprons, and rubber gloves shall be provided for workmen handling acids in accordance with paragraphs (b)(2) and (d)(1) of this section.

(4) *Walkways.* Steps and footwalks along the fourdrinier and press section shall have nonslip surfacing and be complete with standard handrails, when practical, in accordance with paragraph (b)(3) of this section.

(5) *Floor openings.* All flush floor openings in the bottom of the wire pit should be guarded with a barrier-type guard.

(6) *Steps.* Steps of uniform rise and tread with nonslip surfaces shall be provided at each press in accordance with American National Standard A12.1—1967.

(7) *Plank walkways.* A removable plank shall be provided along each press, with standard guardrails installed. The planks shall have nonslip surfaces in accordance with paragraph (b)(3) of this section.

(8) *Dryer lubrication.* If a gear bearing must be oiled while the machine is in operation, an automatic oiling device to protect the oiler shall be provided, or oil cups and grease fittings shall be placed along the walkways out of reach of hot pipes and dryer gears.

(9) *Levers.* All levers carrying weights shall be constructed so that weights will not slip or fall off.

(10) *First dryer.* Either a permanent guardrail or apron guard or both shall be installed in front of the first dryer in each section in accordance with paragraph (b)(1) of this section.

(11) *Steam and hot-water pipes.* All exposed steam and hot-water pipes within 7 feet of the floor or working platform or within 15 inches measured horizontally from stairways, ramps, or fixed ladders shall be covered with an insulating material, or guarded in such manner as to prevent contact.

(12) *Dryer gears.* Dryer gears shall be guarded excepting where the oilers' walkway is removed out of reach of the gears' nips and spokes and hot pipes in accordance with American National Standard B15.1—1953 (reaffirmed 1958).

(13) *Broke hole.* (i) A guardrail shall be provided at broke holes in accordance with American National Standard A12.1—1967.

(ii) Where pulpers are located directly below the broke hole on a paper machine and where the broke hole opening is large enough to permit a worker to fall through, any employee pushing broke down the hole shall wear a safety belt attached to a safety belt line. The safety belt line shall be fastened in such a manner that it is impossible for the person to fall into the pulper.

(iii) An alarm bell or a flashing light shall be actuated before dropping material through the broke hole.

(14) *Feeder belt.* A feeder belt or other effective device shall be provided for starting paper through the calendar stack.

(15) *Steps.* Steps or ladders of uniform rise and tread with nonslip surfaces shall be provided at each calendar stack. Handrails and hand grips shall be provided at each calendar stack in accordance with American National Standard A12.1—1967.

(16) *Grounding.* All calendar stacks and spreader bars shall be grounded as protection against shock induced by static electricity in accordance with the requirements of § 1910.314.

(17) *Sole plates.* All exposed sole plates between dryers, calenders, reels, and rewinders shall have a nonskid surface.

(18) *Nip points.* The hazard of the nip points on all calender rolls shall be eliminated or minimized by means of an effective barrier device, or by feeding the paper into the rolls by means of a rope carrier, air jets, or hand feeding devices. Nips where paper is not being fed into the calender should be protected by barriers. Adequate nip warning signs should be used at all nip points that cannot be guarded physically.

(19) *Platforms.* (i) A nonslip walkway with standard handrail should be provided on both sides of the stacks, in accordance with the American National Standard A12.1—1967.

(ii) A nonslip platform should also be provided at the top of the calender stack if access to that area is required for changing rolls.

(20) *Scrapers.* Alloy steel scrapers with pullthrough blades approximately 3 by 5 inches in size shall be used to remove "scabs" from calender rolls.

(21) *Illumination.* Permanent lighting shall be installed in all areas where employees are required to make machine adjustments and sheet transfers in accordance with the American National Standard A11.1—1965 (R 1970).

(22) *Control panels.* Floor stand panels should be protected from being hit by moving equipment. All control panel handles and buttons shall be protected from accidental contact.

(23) [Reserved]

(24) *Lifting reels.* (i) The reels shall stop rotating before being lifted from bearings.

(ii) All lifting equipment (clamps, cables, and slings) shall be maintained in a safe condition and inspected regularly.

(iii) Reel shafts with square block ends shall be guarded.

(25) *Feeder belts.* Feeder belts, carrier ropes, air carriage, or other equally effective means shall be provided for starting paper into the nip or drum-type reels.

(26) *Inrunning nip.* (i) Where the nipping points of all drum winders and rewinders is on the operator's side, it shall be guarded by barrier guards interlocked with the drive mechanism.

(ii) A zero speed switch should be installed to prevent the guard from being raised while the roll is turning.

(27) *Core collars.* Set screws for securing core collars to winding and unwinding shafts shall not protrude above the face of the collar. All edges of the collar with which an operator's hand comes in contact shall be beveled to remove all sharp corners.

(28) *Slitter knives.* Slitter knives shall be guarded so as to prevent accidental contact. Carriers shall be provided and used for transportation of slitter knives.

(29) *Winder shaft.* All shafts should be equipped with a winder collar guide. The winder shall have a guide rail to align the shaft for easy entrance into the opened rewind shaft bearing housings. If the winder is large and the rewind shafts are too heavy for manual insertion, powered rewind shaft injectors should be employed.

(30) *Core shaft.* When the core shaft weighs in excess of the safe standard, a mechanical device such as a dolly shall be provided for carrying all or part of the weight when it is being removed from the set of paper and placed in the dressing brackets on the winder. In the event that the force required to extract the shaft from the cores is excessive, even though the weight of the shaft is being supported, a powered shaft puller should be employed to relieve the operator of physical strain.

(31) *Winder area.* A nonskid surface shall be provided in the front vicinity of the winder to prevent accidental slipping.

(32) *Radiation.* Special standards regarding the use of radiation equipment shall be posted and followed as required by § 1910.96.

(l) *Finishing room*—(1) *Cleaning rolls.* Rolls shall be cleaned only on the outrunning side.

(2) *Emergency stops.* Electrically or manually operated quick power disconnecting devices, interlocked with braking action, shall be provided on all operating sides of the machine within easy reach of all employees. These devices shall be tested by making use of them when stopping the machine.

(3) *Core collars.* The requirements of paragraph (k)(27) of this section and the American National Standard B15.1—1953 (reaffirmed 1958) shall apply.

(4) *Elevators.* These shall be in accordance with American National Standard A17.1—1965.

(5) *Control panels.* The requirements of paragraph (k)(22) of this section shall apply.

(6) *Guillotine-type cutters.* (i) Each guillotine-type cutter shall be equipped with a control which requires the operator and his helper, if any, to use both hands to engage the clutch.

(ii) Each guillotine-type cutter shall be equipped with a nonrepeat device.

(iii) Carriers shall be provided and used for transportation of guillotine-type cutter knives.

(7) *Rotary cutter.* (i) On single-knife machines a guard shall be provided at a point of contact to the knife.

(ii) On duplex cutters the protection required for single-knife machines shall be provided for the first knife, and a hood shall be provided for the second knife.

(iii) Safe access shall be provided to the knives of a rotary cutter by means of catwalks with nonslip surfaces, railings, and toeboards in accordance with paragraph (b)(3) of this section.

(iv) A guard shall be provided for the spreader or squeeze roll at the nip side on sheet cutters.

(v) Electrically or manually operated quick power disconnecting devices with adequate braking action shall be provided on all operating sides of the machine within easy reach of all operators.

(vi) The outside slitters shall be guarded.

(8) *Platers.* (i) A guard shall be arranged across the face of the rolls to serve as a warning that the operator's hand is approaching the danger zone.

(ii) A quick power disconnecting device shall be installed on each machine within easy reach of the operator.

(9) *Finishing room rewinders.* (i) The nipping points of all drum winders and rewinders located on the operator's side shall be guarded by either automatic or manually operated barrier guards of sufficient height to protect fully anyone working around them. The barrier guard shall be interlocked with the drive mechanism to prevent operating above jog speed without the guard in place.

A zero speed switch should be installed to prevent the guard from being raised while the roll is turning.

(ii) A nonskid surface shall be provided in front of the rewinder to prevent an employee from slipping in accordance with paragraph (b)(3) of this section.

(iii) Mechanical lifting devices shall be provided for placing and removing rolls from the machine.

(10) *Control panels.* The requirements of paragraph (k) (22) of this section shall apply.

(11) *Roll-type embosser.* The nipping point located on the operator's side shall be guarded by either automatic or manually operated barrier guards interlocked with the drive.

(12) *Sorting and counting tables.* (i) Tables shall be smooth and free from splinters, with edges and corners rounded.

(ii) Paddles shall be smooth and free from splinters.

(13) *Roll splitters.* The nip point and cutter knife shall be guarded by either automatic or manually operated barrier guards.

(m) *Materials handling*—(1) *Hand trucks.* No person shall be permitted to ride on a powered hand truck unless it is so designed by the manufacturer. A limit switch shall be on operating handle—30 degrees each way from a 45-degree angle up and down.

(2) *Power trucks.* Power trucks shall comply with American National Standard B56.1—1969. Adequate ventilation shall be provided and the trucks properly maintained, so that dangerous concentrations of carbon monoxide cannot be generated, especially in warehouses or other isolated areas of a plant.

(3) *Cartons.* The carton-stitching machine shall be guarded to prevent the operator from coming in contact with the stitching head.

(4) *Banding of skids, cartons, cases, etc.* Banders and helpers shall wear eye protection equipment in accordance with paragraph (b)(2) of this section.

(5) *Unloading cars or trucks.* (i) Where steel bands or wires are used in boxcars or trucks, all loaders and helpers shall wear eye protection in accordance with paragraph (b)(2) of this section.

(ii) The construction and use of bridge or dock plates shall conform to the requirements of American National Standard B56.1—1969.

(iii) Flag signals, derails, or other protective devices shall be used to protect men during switching operations. The blue flag policy shall be invoked according to paragraph (c)(9)(i) of this section.

(n) *Effective dates.* (1) The provisions of this § 1910.261 shall become effective on August 27, 1971, except as provided in the remaining subparagraphs of this paragraph.

(2) The following provisions shall become effective on February 15, 1972:

§ 1910.261 (a)(3), (b)(6), (f)(2)(iv), (f)(5), (g)(1)(iv), (g)(11)(i), (j)(5)(iv), (k)(12), (k)(32), and (m)(2).

(3) Notwithstanding anything in paragraph (n) (1), (2), or (4) of this section, any provision in any other paragraph of this section which contains in itself a specific effective date or time limitation shall become effective on such date or shall apply in accordance with such limitation.

(4) Notwithstanding paragraph (n)(1) of this section, if any standard in 41 CFR Part 50-204, other than a national consensus standard incorporated by reference in § 50-204.2(a)(1) is or becomes applicable at any time to any employment and place of employment, by virtue of the Walsh-Healey Public Contracts Act, or the Service Contract Act of 1965, or the National Foundation on Arts and Humanities Act of 1965, any corresponding established Federal standard in this § 1910.261 which is derived from 41 CFR Part 50-204 shall also become effective, and shall be applicable to such employment and place of employment, on the same date.

(Secs. 4(b)(2), 6(b) and 8(c), 84 Stat. 1592, 1593, 1596, 29 U.S.C. 653, 655, 657; Secretary of Labor's Order No. 8-76 (41 FR 25059); 29 CFR Part 1911)

[39 FR 23502, June 27, 1974, as amended at 40 FR 23073, May 28, 1975; 43 FR 49751, Oct. 24, 1978]

GLOSSARY

Attrition Mill - A refiner containing fixed and rotating discs between which wood chips pass on a stream of water (used in pulping for building paper and board making).

Barking - The operation of removing bark from pulpwood prior to chipping and screening. This is carried out by means of a knife (disk), drum, abrasion, hydraulic barker, or by chemical means.

Beater - A large mixing tub where pulp or wastepaper fiber is mixed with various additives, such as fillers, dyes and sizes. The action of the beater also serves to separate the pulp fibers.

Billets - Short lengths of logs used in the mechanical pulping process.

Black Liquor - The spent liquid obtained from the pulp-washing system. The composition varies considerably in different mills and from different methods of cooking. It is distinctly alkaline, but not caustic. It has an intense black color.

Black Liquor Oxidation - Refers to process unit in the kraft liquor recovery system through which the black liquor passes before it goes through evaporation. Air is pumped into the oxidation tower as a pollution control measure in order to rende the reduced sulfur emissions less volatile.

Bleach Requirement - The amount of bleaching agent, expressed in terms of available chlorine, required to produce a specified brightness in a pulp.

Bleached Pulp - Refers to all chemical and mechanical pulps that are bleached.

Bleaching - The process of chemically treating pulp fibers to reduce or remove coloring matter so that the pulp is improved in terms of whiteness or brightness.

Blow - Ejection of the chips from a digester, or waste solids from a boiler.

Blowdown - 1) The liquid and solid waste materials ejected from a pressure vessel such as a boiler. 2) Use of a compressed air line and hand-held jet nozzle to blow settled dust from dry-end paper machine equipment and work surfaces.

Blow Pit or Blow Tank - A large tank under a digester which receives the discharged chips and liquor from the digester. A constructed stainless steel plate within the blow pit acts to break up the chip structure into individual fibers of pulp upon impact.

Brightness - The light-reflecting property of paper, measured against a reference standard.

Bristols - A general term for a solid or laminated heavyweight printing paper made to a thickness of .006" or higher. The name is derived from the original pasted rag content board made in Bristol, England.

Broke - Trimmings, manufacturing waste or damaged paper generated in a papermill.

Brown Stock Washers - Refers to a process unit in chemical pulping, usually composed of several stages, which removes spent cooking liquor from the unbleached pulp stock.

Calender - An assembly of rolls at the end of the paper machine imparting a final finish to the paper, increasing gloss and smoothness.

Calender-Finished - Any paper with a surface glazed by calenders, such as machine finish, English finish, supercalendered and calender-friction glazed.

Calendering - The operation of finishing a sheet of paper by passing it through a calender or supercalender.

Causticizing - The process of reacting green liquor with slaked lime to form white liquor.

Chemical Pulp - Pulp obtained by the cooking of wood in an aqueous solution of various chemicals. The principal chemical processes are the sulfite and bisulfite, sulfate or alkaline (kraft) and soda.

Chest or Stock Chest - A tank used for storage of wet fiber or furnish.

Chip - A small piece of wood produced by a chipper in a form suitable for processing into wood pulp or for use as fuel.

Chipper - A machine consisting essentially of a revolving disk equipped with heavy radially-arranged knives, which cuts pulpwood and sawmill waste into slices or chips, diagonal to the grain.

Classifier - A screen or similar device used to sift out "grit" from the lime slaker before it is sent to waste.

Coating - The layer of mixed clays and adhesives and so forth that is applied to the surface of paper or paperboard to create a new surface.

Color - Refers to standard APHA Platinum Cobalt Test, using standard for color intensity of water samples. Commonly, standards are prepared at various concentrations which later may be referenced as units of color, derived from flow and concentration standard.

Converting - Any operation in which paper is made into a product, not necessarily the final product to be made.

Condenser - Any of a number of towers where relief gases (i.e., from the digester) are condensed and sewered.

Cooking - Treating raw materials with chemicals under pressure and extreme heat to produce pulp for papermaking. Also referred to as "pulping."

Cord - The amount of wood contained in a pile of logs measuring 4 ft x 4 ft x 8 ft (128 ft^3), approximately 85 ft^3 of solid wood.

Couch Pit - A pit or catch basin located under the couch roll on a fourdrinier machine to receive water removed at the couch or wet broke in case of a wet end break.

Couch Roll - A paper machine roll primarily involved in 1) dewatering and picking off, or couching, of the newly formed paper web from the wire on which it was formed and partially dewatered, and 2) the transfer of the web to the wet press felt for further dewatering.

Countercurrent Washing - Refers to a method of washing used on the bleach plant or brownstock washers where fresh water is applied on the last stage showers, and the effluent from each stage is used on the washer showers of the preceding stage.

Cyclone - A dust collecting device.

Cylinder Machine - A paper machine utilizing wire-covered cylinders or molds in which a web is formed from a dilute stock suspension.

Dandy - A skeleton roll, covered with wire cloth and supported above the fourdrinier wire. It rides on the wet web of paper of a fourdrinier machine at a point near the first suction box for the purpose of marking the sheet with a design carried on the surface of the roll.

Decker - Piece of equipment commonly used to thicken pulp. It consists of a wire covered drum in a pulp vat. A vacuum is applied to the center of the drum, commonly by a barometric leg, to pull water out of the stock slurry.

Deflaker - A high-speed mixing and agitating machine through which a fibrous stock suspension in water is pumped to obtain complete separation and dispersion of each individual fiber, and break up of any fiber lumps, knots, or bits of undefibered paper.

Deinking - The removal of ink, filler and other extraneous materials from printed or unprinted reclaimed papers through a combination of mechanical disintegration and chemical treatment, followed by washing, and, usually, bleaching. Flotation methods are also used to remove inks.

Delignification - The process of removing lignin from wood by means of chemicals, leaving a residue of cellulose, hemicellulose, and other carbohydrate materials.

Die Cut - The process by which paper or board is cut or stamped out to a specified shape or size with a steel die.

Digester - Large reactor vessel in which wood chips are cooked in an aqueous solution to form chemical pulp.

Direct Contact Evaporator - Refers to process unit in alkaline pulping where black liquor is further concentrated or evaporated by coming into contact with hot flue gases. It is then pumped into the salt cake mix tank and sprayed into the recovery furnace.

Disc Mill - See fiberizing.

Dissolving Pulp - A special grade of pulp produced by either the kraft or sulfite processes using strong chemical solutions for both pulping and bleaching. The resulting highly purified pulp contains virtually no lignin and is used in the manufacture of regenerated cellulose (viscose rayon and cellophane) or cellulose derivatives such as acetate and nitrate.

Dregs - The inert rejects from the green liquor clarifier in a kraft pulp mill.

Drier Hood - A covering over the whole or part of the drier section of the paper machine or coating unit which serves to collect the hot moisture-laden air from the drying process and exhaust it through suitable fans and duct work.

Driers - Steam-heated, hollow metal cylinders that dry paper as it passes around them in the paper machine.

Dry End - The end of the paper machine from which finished paper is dried and wound onto a reel.

Evaporator - Refers to multiple effect evaporation and direct contact evaporation through which black liquor passes to be concentrated before it enters the recovery furnace.

Felt - A continuous belt made of wool or various combinations of wool, cotton, asbestos and/or synthetic fibers. Felts move the sheet through the paper machine, serving as a cushion and a medium for water removal.

Felt Side - The side of the paper web that has not been in contact with the wire during manufacture; the top side of the sheet.

Fiber - The threadlike units of vegetable growth that supply the structural basis of paper; also, synthetic filaments used in paper or other sheet materials ("synthetic fiber"). See also Secondary fiber.

Fiberizing - A process for the reduction of fiber aggregates to individual fibers from such sources as wood chips, pulp sheets, dry broke and reclaimed paper stock. It is usually accomplished by mechanical equipment such as disc mills, conical refiners and vortex pulpers. The raw materials may or may not have been softened by water, steam, or chemical treatment prior to mechanical action.

Filler - A mineral pigment added to the fiber furnish to improve the opacity, color or printing qualities of paper.

Fine Paper - A broad term including printing, writing, and cover papers, as distinguished from wrapping and other coarse papers, business communication papers.

Finish - The surface property of a paper sheet determined by its surface contour and gloss (antique, eggshell, vellum, machine, English, supercalendered, plate).

Finishing - The various operations in the manufacture and packaging of paper performed after it leaves the paper machine. Finishing operations include supercalendering, plating, slitting, rewinding, sheeting, trimming, sorting, counting, and packaging. Ruling, punching, pasting, folding, and embossing are also sometimes considered as finishing operations.

Formation - A property of paper that is determined by the degree of uniformity of distribution of the solid components of the sheet with special reference to the fibers.

Fourdrinier - A paper machine utilizing a horizontal, moving, fine-mesh screen to form paper from a very dilute slurry of pulp and water.

Furnish - The mixture of various materials (pulp, sizes, wet-strenth or other additives, fillers and/or dyes) that are blended in the stock suspension from which paper or paperboard is made.

Green Liquor - A liquid produced in the kraft process by passing the smelt into a dissolving tank.

Grinder - A machine for producing mechanical wood pulp or groundwood. It is essentially a rotating pulpstone against which logs are pressed and reduced to pulp.

Hardwood - Wood from deciduous trees, having short fibers.

Headbox - (1) On fourdrinier machines: A large flow control chamber which receives the dilute paper stock or furnish from the stock preparation system and, by means of baffles and other flow-evening devices, maintains sufficient agitation of the mixture to prevent flocculation of the fibers, spreads the flow evenly to the full width of the paper machine and provides delivery of stock to the fourdrinier wire uniformly across its full width. (2) On cylinder machines: A flow-regulating device which controls the volume of stock flowing to the screens and mixing boxes before the vats.

Hog Fuel - Wood waste materials, including bark, shavings, sander dust, log yard cleanup, and sawdust.

Integrated Paper Mill - A paper mill that produces all or almost all of the pulp it uses in papermaking.

Junker - A centrifugal action collector, which removes extraneous solids during the repulping of waste paper.

Knot - An imperfection in paper or lumps in paper stock resulting from: (1) incompletely defibered textile materials; the term applies especially to rag paper manufacture; (2) small undefibered clusters of wood pulp; and (3) the basal portion of a branch or limb which has become incorporated in the body of the tree.

Knotter - Refers to a process unit in pulping operations where unwashed pulp is deknotted: undefibrated, partially cooked wood particles or knotts are removed.

Lime Kiln - Furnace in kraft and soda pulping processes where lime "mud" or calcium carbonate is burned to "quicklime" (calcium oxide), which reacts with sodium carbonate in green liquor to form sodium hydroxide.

Machine Aids - Additives used during papermaking such as defoamers (foam control agents), retention aids, pitch control agents, formation and drainage aids, lubricants, surfactants and biocides (slimicides).

Machine Finish (MF) - Any finish on a paper machine. It may be that of the sheet as it leaves the last dryer or as it leaves the calender stack, and either a dry or wet finish.

Market Pulp - Wood produced for, and sold on, the open market, as opposed to that which is produced for internal comsumption by an integrated pulp and paper mill.

Mechanical Pulp - Pulp produced by mechanical rather than chemical processes; includes stone groundwood, refiner groundwood, thermomechanical, defibrated and exploded pulp.

Mixing Chest - Process unit where pulp is mixed with desired additives before papermaking.

Mud Filter - A piece of equipment used to thicken and wash lime mud prior to burning it in a lime kiln.

Mud Washer - A piece of equipment used to wash the sodium base chemicals from the lime mud prior to burning it in the lime kiln.

Non-Integrated Paper Mill - A mill that produces none of the pulp it uses for papermaking.

Opacity - The property of a sheet of paper that obstructs the passage of light and prevents print or any object on or in contact with the other side from being seen through the sheet; the opposite of "showthrough."

Papergrade Pulp - Fully bleached chemical pulp suitable for fine paper, writing and business paper.

Pigment - A mineral or organic additive used to color paper or coating, or to develop opacity.

Porosity - The degree to which a paper contains connected air pockets. Porosity affects the absorbency of a paper, and is measured by determining the rate of air flow through a given sheet of paper in a densometer.

Precipitators - Equipment used to remove ash and other fine solids from gases exiting the boilers and furnaces in a mill.

Pulper - A machine designed to break up, defiber, and disperse dry pulps, mill process broke, commercial waste papers, or other fibrous materials into slush form preparatory to further processing and conversion into paper or paperboard. It normally consists of a tank or chest with suitable agitation to accomplish the dispersion with a minimum consumption of power.

Pulpwood - Those woods which are suitable for the manufacture of wood pulp. The wood may be in the form of logs as they come from the forest or cut into shorter lengths suitable for the chipper or the grinder. The term may also be applied generically to chips produced from roundwood or from whole trees remote from the pulpmill.

Pulpwood Preparation - Sequence of processes for preparing tree logs (roundwood) for mechanical or chemical pulping. This includes slashing and splitting of logs, barking, chipping and screening of chips.

Recovery Furnace - In wood pulping, a unit for concentrating black liquor to a stage where the residual carbon is then burned out and the inorganic sodium salts melted and recovered.

Red Liquor - Spent liquor in the sulfite pulping process after it is separated from the pulp.

Refiner - A machine used to rub, macerate, bruise, and cut fibrous material, usually cellulose, in water suspension to convert the raw fiber into a form suitable for formation into a web of desired characterisitics on a paper machine. The many types of refiners differ in size and design features but most can be classified as either jordans or disk refiners.

Refining - The mechanical treatment of pulp in a water suspension to convert the fiber into a form suitable for papermaking.

Rewinder or Winder - The term rewinder is often used for the winder in the finishing room, distinguishing it from the winder which follows the slitter at the end of the papermachine.

Rotoformer - A paper-forming device used to manufacture single or multi-ply grades of paper and paperboard. It consists essentially of a wire-covered drilled shell on which the stock is formed, suction boxes inside the shell to remove water, and a restricted forming area in the upper quadrant of the upturning side of the cylinder.

Saveall - An apparatus used for reclaiming fibers and fillers from white water. It usually operates on a filtration, sedimentation, flocculation, or flotation principle.

Screening - The operation of passing chips over screens to remove sawdust, slivers, and oversize chips. (2) the operation of passing pulp or paper stock through a screen to reject coarse fibers, slivers, shives, knots, etc.

Screenings - Knots of pulp and other materials too coarse to pass through pulp or stock screens, separated or screened from the stock before it contacts the paper machine wire. Screenings are often used to make coarse papers or paperboards.

Secondary Fiber - Fiber that has been previously used for papermaking, including stock reclaimed from wastepaper as well as broke.

Shive - A bundle of incompletely separated fibers which may appear in the finished sheet as an imperfection.

Shredder - Agitator chest where pulp from the NSSC process is mixed with white water from the paper mill.

Size - Any substance used in or on paper to make it water or ink-resistant, such as rosin, glue, gelatin, starch, latex, synthetic resins.

Size Press - The section near the end of the paper machine where paper is surface-treated with starch or other solutions.

Slasher - A saw or set of saws used to cut long logs to desired length.

Slaker - Refers to a process unit in kraft and soda processes where calcium oxide (lime) is reacted with water to form calcium hydroxide. Form there it is routed to the causticizer.

Slitter - A machine-direction web cutting device which is mounted on a rewinder or other machine for transforming large parent rolls into rolls having narrower widths.

Slurry - A suspension in water or adhesive solution of pigments or other insoluble materials used in coating or papermaking.

Smelt - Molten sodium carbonate and sodium sulfide obtained from the recovery furnace and redissolved to form green liquor.

Smelt Dissolving Tank - Refers to a process unit in kraft liquor recovery where smelt from the recovery furnace is dissolved in water to form green liquor.

Softwood - Wood from coniferous trees, having long fibers.

Spent Liquor - Cooking liquor that has been used in the manufacture of chemical pulp and that contains lignin, resins, and other substances extracted from wood.

Splitter - A machine which quarters large logs before they enter the chipper machine.

Stock - (1) Pulp which has been beaten and refined, treated with sizing, color, filler, etc. and which, after dilution, is ready to be formed into a sheet of paper, (2) Wet pulp of any type at any stage in the manufacturing process, (3) Paper or other material to be printed, especially the paper for a particular piece of work, (4) A term used to describe a paper suitable for an indicated use, such as coating raw stock, milk carton stock, tag stock and towel stock.

Stock Preparation - A term for the several operations which occur between pulping (or bleaching) and formation of the web on a papermachine. It may include, for example, repulping, beating, refining, and cleaning.

Stuff Box - Process unit where pulp and additive mixes are routed for adjustment of consistency.

Supercalender - Off-machine calender rolls that heat and iron paper to produce a high-gloss finish.

Supercalendered Finish - A finish obtained by passing paper between the rolls of a supercalender under pressure.

Surface Coloring - The application of color to paper after the web has been formed on the paper machine; may be done on-machine at the calender rolls or off-machine as a separate operation.

Surface-Coated - Term applied to paper or paperboard where one or both sides are coated with a pigment or other coating material.

Synthetic Fiber - Any man-made fiber, including those derived from cellulose, such as rayon and acetate, as well as the purely man-made, such as nylon and acrylic fiber.

Twin-Wire Machine - A paper machine using two wires. Sections of the two wires are close to each other and parallel. A pulp slurry is injected between the two wires and water is removed from both sides of the sheet of paper as it is formed.

Unbleached Pulp - Refers to pulp produced by the kraft (sulfate) process that is not bleached. The products include linerboard, wrapping paper and paper for grocery bags and shipping sacks.

Web - The continuous sheet of paper coming from the paper machine in its full width or from a roll of paper in any converting operation.

Wet End - The end of a paper machine where the pulp slurry is introduced for formation into paper.

Wet Press - The dewatering unit used on a paper machine between the sheet-forming equipment and the drier section. It applies pressure, or a combination of pressure and suction to the sheet to remove as much water as practical from the sheet ahead.

Wet Strength - The tensile strength of a sheet of paper when completely wet; sometimes calculated as a percentage of its dry strength.

Wet-Strength Paper - Paper with an extremely high resistance to tearing or disintegration when completely wet. To qualify as wet-strength paper, a sheet must retain over 15% of its dry tensile strength when saturated with water.

White Liquor - Kraft cooking liquor (contains sodium hydroxide and sodium sulfide in water solution).

White Water - All waters of a paper mill which have been separated from the stock or pulp suspension, either on the paper machine or accessory equipment, such as thickeners, washers, and savealls, and also from pulp grinders. It carries a certain amount of fiber and may contain varying amounts of fillers, dyestuffs, etc.

Yankee Machine - A type of fourdrinier or cylinder machine having a single drying cylinder with a highly polished surface, used for making machine-glazed paper or for drying tissue.